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Pleistocene shorelines in the Western Cape and South-West Africa

by

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SYNOPSIS

This paper describes detailed investigations of the exposed shorelines of the Atlantic coast of southern Africa as far north as R. Olifants and between Walvis Bay and R. Ugab, and summaries of those in the intervening stretch which is controlled by the diamond-companies. It is not possible to travel north of R. Ugab.

Most of the coastal plain is blanketed with terrestrial wash and blown sand, which have concealed practically all exposures above 18 m. In the low-level beaches is abundant cold-water fauna of modern species, from which radiocarbon-dates, not very reliable, have been obtained for the sea-levels up to 9 m. Artefacts are very scarce.

South of the Berg River there is practically no evidence for higher shorelines, and it is doubtful if they exist. Near R. Olifants is a good terrace at about 30 m occasionally carrying warm-water fauna, to which grades the principal river-terrace with rolled Early-Middle Acheulian artefacts. In this valley there is one higher terrace, and evidence for deep entrenchment after the 30-metre gravel.

In the Namaqualand diggings marine terraces at about 23 m, 38 m and 50 m, each with distinctive warm-water fauna, have been identified, and there are higher terraces which are sterile. Artefacts of Acheulian and more primitive types have been found at Kleinzee and Alexander Bay. It has not been possible to survey satisfactorily the terraces of R. Orange.

In contrast to the south of R. Orange, in South West Africa there are no pleistocene shorelines either near Orange Mouth or north of Walvis Bay above 30 m. The 'oyster-line' at 25–30 m, marked by abundant *Crassostrea margaritacea* which is regarded as a warm-water indicator, can be traced along the coast. Cold-water species are found in lower beaches. There are a few artefacts from Orange Mouth, primitive pieces in the higher gravels and hand-axes in a gravel with cliff-base at 5 m; farther north there are no human remains. North of Walvis Bay an intertidal platform may be older than the 28-metre gravel and have been formed during an Early-Middle pleistocene emergence.

INTRODUCTION

This is the fourth and last of my papers describing the pleistocene shorelines of South and South West Africa. The field-work for this project has been carried out over the last few years on behalf of the Shorelines Commission of the International Quaternary Association, with the aid of grants from the Council for Scientific and Industrial Research, sponsored by the Department of Geography of the University of Natal. The previous papers have been published in this Journal (Davies 1970, 1971, 1972).

This paper is less exhaustive than the others, because long stretches of the Atlantic coast of southern Africa are tightly controlled diamondiferous areas, to which I have been able to pay only rapid visits. Moreover, most of the companies' coastlines are under continuous examination by their resident geologists, who will be able to present a far more detailed and correct account than I can. The diamonds occur in marine gravels, largely on fossil beaches, whose exact morphology is of prime interest to the mining companies. Artefacts are much rarer in the western coastal gravels than on the south and east of South Africa. On the other hand, the fauna of the older beaches is more distinctive, and has been studied by the local geologists; whereas in the south Cape the older fauna is disappointing.

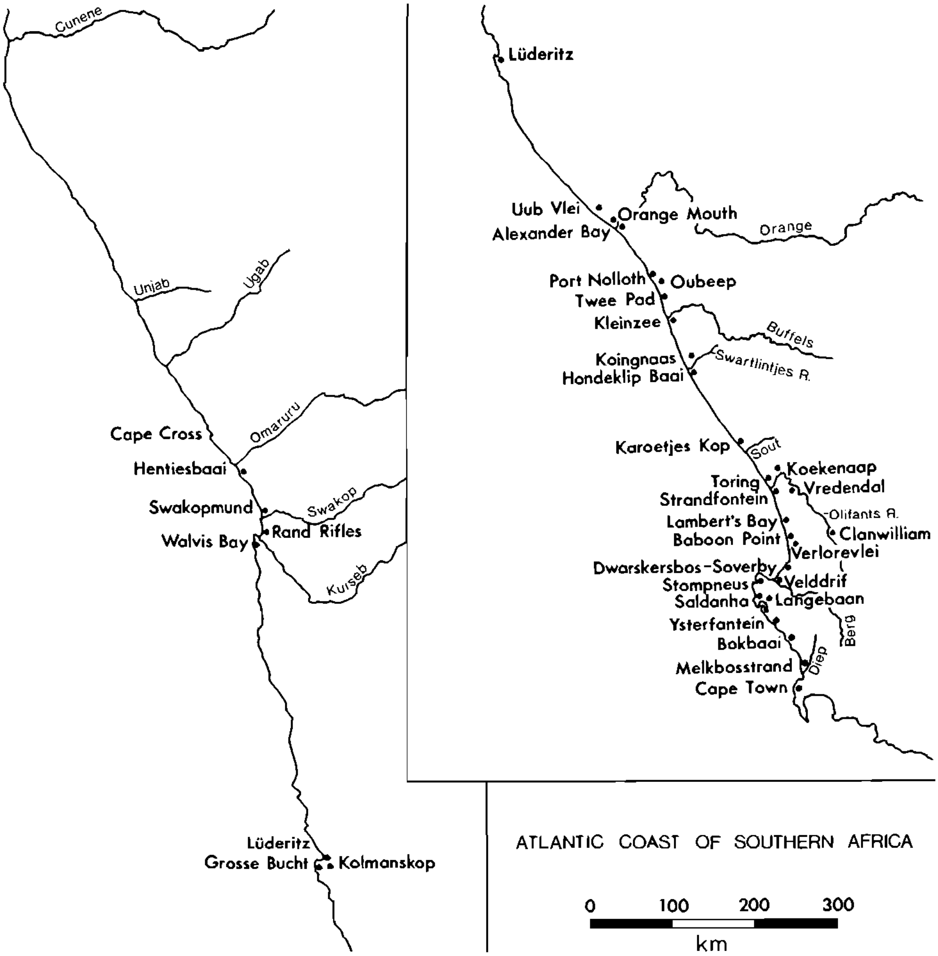
Cunene
Unjab
Ugab
Omaruru
Cape Cross
Hentiesbaai
Swakopmund
Swakop
Walvis Bay
Rand Rifles
Kuiseb
Lüderitz
Grosse Bucht
Kolmanskop
Lüderitz
Uub Vlei
Orange Mouth
Alexander Bay
Orange
Port Nolloth
Oubeep
Twee Pad
Kleinzee
Buffels
Koingnaas
Swartlintjes R.
Hondeklip Baai
Karoetjes Kop
Sout
Koekenaap
Toring
Vredendal
Strandfontein
Olifants R.
Lambert's Bay
Clanwilliam
Baboon Point
Verlorevlei
Dwarskersbos-Soverby
Velddrif
Stompneus
Saldanha
Langebaan
Ysterfontein
Berg
Bokbaai
Diep
Melkbosstrand
Cape Town
ATLANTIC COAST OF SOUTHERN AFRICA
0
100
200
300
km

Figure 1

Since the Middle Pleistocene the west coast appears to have been markedly stable; beaches over 1 500 km vary in altitude by at most a few metres. But on long stretches the early pleistocene beaches have disappeared. It does not therefore seem necessary to illustrate this paper with more than a horizontal map (fig. 1) to indicate localities of the main sites.

Most of the shore-sites have a number, taken from duplicated schedules prepared for the Shorelines Commission. Artefacts are quoted by their inventory number in the Natal Museum (N.M.); so far as I know, there are no other collections of artefacts from beach-gravels on the Atlantic coast. Isotopic dates are quoted by their laboratory numbers; it is hoped that others will be obtained, especially by the thorium method, as radiocarbon-dates of shells do not seem entirely trustworthy.

The following abbreviations are commonly used:

L.S.A.	Late stone-age
M.S.A.	Middle stone-age
M.S.L.	Mean sea-level
S.L.	Sea-level
T.M.S.	Table Mountain Sandstone

CAPE TOWN TO BERG RIVER, THE SANDVELD COASTS

Much of the coast between Cape Town and the Berg River is sand, probably filling bays;[1] but at intervals there are rock-outcrops, on which quaternary marine terraces should have been cut and preserved. Nevertheless, I know only one site on this coast at about 30 m, perhaps two at 18 m; all the others are at 9 m or less. It seems that the granite and shales weather to irregular forms which do not preserve ancient marine features. Most of the coastal zone is rolling country overlain by thick sand. Even where fairly high hills approach the coast, there is either a low platform to a steep rise without trace of marine terraces, as at the outer end of Langebaan peninsula; or a steep rise almost from the shore, as near St Helena Bay fishing-settlement; or above steep cliffs a plateau very gently rising from about 15 m S.L., as near Bokpunt.

Several studies have been published on the Sandveld in the Hopefield area, in connection with the middle-pleistocene mammal-site at Elandsfontein (usually known as the Hopefield site) and with the fossils from the phosphate-mines at Langebaanweg. About the age of the latter there has been much discussion. Hendey's latest conclusion (1970*b*) is that the fauna is pliocene, and the beds belong to a pliocene high sea-level, for which there is evidence in Namaqualand; this was there followed by a regression; and fairly early in the Pleistocene a fresh transgression, probably to a higher level than the pliocene one, overrode and eroded the pliocene beds except from protected pockets.

Singer & Wymer (1968) describe a marine level of sands west of Hopefield at 100 m S.L.; this figure seems to be a guess. Mabbutt (1956) claims more vaguely a platform cut in Malmesbury shales at 90 m, overlain by older sands. Apart from general appearance, there seems to be no direct evidence for marine planation or for its date, which both authors claim to be tertiary. They agree that surface-sands have been completely disturbed by aeolian action and that no true marine sands have been found. No general picture of the underlying rock has been formed, and beneath the surficial loose sands are calcified sands of unknown depth. The claimed 90-metre platform is bounded on west and south-west by higher isolated hills, and is truncated on east and south by the Soutrivier which flows through Hopefield, and by its tributary the Groenrivier.

There is rather better evidence for a 60-metre marine platform, but again no direct proof. At Sandvlei crossroads east of Hopefield (C 153) is a rock-outcrop which may be the edge of a terrace at just over 60 m, incised by the wide Soutrivier valley. Mabbutt claims a fragmentary terrace at 45–60 m overlooking Langebaan Lagoon. He also notes ridges of calcified dune running north–south, which would line successively lower shores towards Saldanha Bay.

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[1] e.g. at Paternoster, there is a marine deposit at −16 — −21 m S.L., overlain by aeolianite (Du Toit 1917: 12). There are considerable depths of pleistocene terrestrial sand on the Cape Flats; cp. terrestrial deposits dated >40 000 at Riet Vlei, GrN 5 550–1 (Vogel 1970: 453); and wood at −4 m at Athlone dated >40 500, Pta 171 (Vogel & Marais 1971: 382). The outer peninsula of Langebaan Lagoon appears to be a dune-ridge connecting the granite island at its tip with the rocky point of Ysterfontein.

The picture is complicated by the phosphate-beds at about 30 m S.L. at Langebaanweg (Hendey 1970*a*, 1970*b*), which have been claimed to mark a fossil estuary and delta of the Berg River. Evidence for the Berg River having, during the Pleistocene, flowed into Saldanha Bay is not satisfactory; the trench to −30 m at its mouth (Du Toit 1917) could have been cut during a low eustatic level by some smaller river. At latest by the 18-metre stage the Berg River must have used its present mouth. There are beds at least 6 m thick of water-laid sands and sub-angular pebbles up to 18 m S.L. at Jantjiesfontein and Kersefontein, continuing a river-terrace which can be traced from Piketberg; and at 12 m farther downstream at Cloeteskraal. These beds must have been laid down by a river flowing to the present mouth. At Otterhoek, 6 km north of Hopefield, similar riverine sand at 24 m was presumably deposited by the Soutrivier grading to the Berg River.

It seems therefore that the existence of pleistocene sea-levels at 90 m and 60 m in the northern Sandveld is inferred from these levels in Namaqualand. The only good evidences for a 30-metre stage are marine pebbles and a probable cliff on the outer coast at Pelgrimsrust north-west of Vredenburg (C160). According to Hendey's reconstruction, the pliocene beds at Langebaanweg were truncated by a transgression to 27 m which left a low cliff. Artefacts have not been found on the beach of this transgression, but there is a possibility that men using fire occupied it and accumulated bones on it. Molluscs of this transgression will certainly have been mixed with those of the pliocene beds. Thus one becomes sceptical of Kensley's claim (1972), taking no account of Hendey's reconstruction, that a collection which he has examined is pliocene; twelve species now live in Saldanha Bay, three on the south and east coasts, and only one is extinct.

Even for the 18-metre sea-level there is little evidence apart from the Berg River terraces. There may be traces of it in a quarry (C149) behind the southern end of Langebaan. Aeolianite covers a granite slope; the base of the dune is stained and has ferricrete concretions. At 18 m S.L. the granite rises steeply; there are aeolianite pebbles loose and in concretions and a very few fragments of marine shells, including a small *Bullia laevissima.* So a marine terrace may have incised the dune, just to the granite. On Schapen Eiland also, off Langebaan, there is a planed platform with shelly sandstone at about 15 m; I could not reach it. The new pit at Geelbek (C187, see Table 1) may have touched beds of this or an older transgression.

The coast between Modder River and Bokbaai consists of cliffs to nearly 15 m, forming the edge of a gently rising plateau. But, except perhaps at Kasteelpoort (C133), I found no indication of a marine-cut terrace or of any but a sub-aerial slope graded to an unknown sea-level west of the present shore.

There is better evidence for a terrace at or just above +9 m. Behind Jutten Point and South Head (C179–80) is a wide terrace; its cliff-base, though concealed by dune, cannot be at more than 11 m. It is cut in granite which has greatly weathered, and in places is overlain by aeolianite, at one point by shelly beach-rock (see Table 1). Parker obtained a date of 48200^{+2600}_{-2200} for 'shell-fragments associated with 3–5 m emerged sea-level, from outcrop on emerged wave-cut terrace at Luisterhoek' (Pta-095; Vogel & Marais 1971: 382); his description is not compatible with any of the terraces on these headlands; his sample probably came from the 9-metre. He got similar dates for shells 'associated with 3–5 metre emerged beach, from outcrop on emerged wave-cut terrace' at Kreeftebaai south-east of South Head (Pta-094, 40200 ± 1300) and for shells, alleged to have been collected from a very hard deposit on a terrace without cliff at 7,8 (or 6,5) m at Elandpunt (C148; Pta-097, 41100 ± 1200 and Pta-098, > 49500); *Polinices* sp. and *Natica* sp. were identified.[2] I have not seen either of these sites, but suspect that both belong to the 9-metre S.L. There seems no evidence for Parker's 15-metre terrace. His geological descriptions are unintelligible; his altitudes do not fit stages known in South Africa and elsewhere; his dates, being minima, are probably worthless; and Mr R. N. Kilburn of the Natal Museum considers that his claim that the shells from Elandpunt indicate warm water is unjustified.

Haughton (1933) describes marine deposits, apparently the head of a beach, at 7,5 m S.L. at Ysterplaat Quarry, Maitland (C83). The fauna (whale, shark, rhinoceros) suggest a beach-ridge perhaps ponding a lagoon. The site is probably a very large excavation south-west of the aerodrome. On the east face coarse fluviatile gravels overlie rotten shale. On the west fine white sand, probably marine, underlies a gritty crust and rests on a rock-surface about 1 m lower than on the east. The beach-ridge was probably in the middle of the quarry, where a slight rise in rock can be traced.

At Bokbaai I observed ferruginized sandstone with a few pebbles at 8–9 m (C128); there is no cliff. This is probably recorded by Mabbutt (1955) at 6,0–7,5 m (ferricrete capping the terrace); his altitude is too low.

At Ysterfontein (C137) terraces are claimed at 20, 13, 9 and 7,5 m. They are difficult to identify, because calcified dune extends to the cliff-edge. In 1953 I saw at about 7,5 m a considerable depth of midden on rock in the quarry at the back of the harbour. This midden accumulated contemporaneously with the dune, but was probably much later than the terrace. Mabbutt (1955) claimed that it overlies a beach; I saw pebbles in a gully, probably not *in situ*, and cemented by dune-rock. The site has been destroyed by extension of the quarry. The terraces claimed at 20 and 13 m can certainly be discounted as midden. There is a well-marked rock-cut terrace without cliff at 9 m round Ysterfontein Point from Hoëbank to Starck's Bank; this may be Krige's (1927) terrace at 7,8 m.

The predominantly warm-water fauna from a quarry just north of Langebaan at +9,5 m (C152, see Table 1), compared with that from Geelbek (C138), suggests that at this period the water of Saldanha Bay was warmer than in the open ocean. Ocean-water may have been warm for a period too short to leave a fossil-record; and during this interval warm species may have entered sheltered waters, where they were later isolated. C152 is probably the quarry described by Haughton (1931), though he gives the altitude as 6 m. No section survives; cemented beach-rock is plastered to loose blocks of aeolianite, which apparently overlay and underlay the beach; Haughton says that it was 1,8 m thick.

The wide flats at the head of Saldanha Bay, which slowly rise to the foot of the hills at about 15 m, seem to preserve a marine level; but they are covered with terrestrial wash which conceals former beaches. The platform may well belong to the 9-metre transgression. The rock behind is a tertiary marine formation overlain by aeolianite.

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[2] Radiocarbon-dates on shells of the order of 40 000 are unreliable and almost certainly indicate ages beyond the range of radiocarbon, both owing to recrystallization of the shells and to the penetration of atmospheric carbon dioxide into the crystal lattice (Olsson & Eriksson 1969). Shells dredged from under water and immediately sealed may give reliable dates; but shells stored in the air or collected from exposures above water do not. Dates of the order of 30 000 are little more reliable, and even tertiary shells may give dates of this order. Dates of < 10 000 may be rather too low, but can be accepted as not far wrong.

There is a fairly continuous terrace at up to +9 m round the Saldanha Peninsula. I have been able to distinguish the exposures as far as the artillery range north of North Head.

The exposure started on the eastern face of the peninsula at the northern end of Smithswinkel Bay (Du Toit 1917; Wybergh 1919; Haughton 1931: 33; site C155, faunal list in Table 1; called by Haughton Hoedjes Bay Cliffs). This stretch is no longer visible; there is now an exposure behind Seaharvest Factory under Hoetjespunt (C186), with platform at 7,3–8,9 m M.S.L.; no cliff is visible, but it mus b very close. Mr Tankard has collected shells. The deposit of boulders and shelly sand is about 1,2 m thick and is overlain by aeolianite.

Apparently at this stage a gulf penetrated south-west from the centre of Smithswinkel Bay. A deep excavation behind the bay has revealed, beneath aeolianite, lagoonal sands at nearly modern S.L., containing articulated shells, modern species apart from *Gastrana matadoa*, which does not today live so far south. I collected one valve at Schrywershoek. The water in this gulf must therefore have been warm.

On the south side of Hoetjespunt are exposures of cemented shelly conglomerate (recorded by Haughton as Hoedjes Bay Peninsula, (south end); see 1931: 33–4 and C156, Table 1). The principal beach, at +6,5 m, rests against a cliff and on a tertiary platform; below the beach is incised a cave with a marine deposit up to 4,2 m. In a small collection which I made from the main beach Mr Kilburn has found nothing save modern species; there are also very large barnacles.

I have no record of exposures round North Bay, though probably during the 6–9 metre transgression it was surrounded by a beach-ridge. The next exposure is at Nordbaaipunt, where a well-marked platform at 6 m carries blocks of cemented shelly beach-rock (C188, see Table 1). Into this is incised a terrace at 3,6 m with uncemented shells (C189). These terraces can be traced all along the coast to North Head Lighthouse and Schooner's Rock, and on Malagas Island.

On the west coast of the peninsula, north of North Head Lighthouse, several trenches have been dug. Close to the lighthouse these have incised beds which fill a former bay (C190; mentioned by Parker (1968) as a terrace at 10½ m and storm-ridges at 12 and 7 m). Beneath black humic sand containing scattered *Patella*, a calcrete crust overlies a beach and probably two storm-ridges. Outside the bay, 1 km to the north, these are distinct. The upper consists of very large pebbles; it rests on granite-sand at +7,0 m and its top is at +11,0 m. The lower is of small pebbles; its base is not exposed, its top is at +7,9 m. There are no cliffs.

I measured two sections in the old bay just north of the lighthouse:

SOUTH. M,S.L.	11,6–11.0 m	Black sand, no shells
	11,0–10,7 m	Calcrete
	10,7–8,5 m	Packed broken shells, calcified but not cemented, mixed with large rounded pebbles, becoming rarer towards east end of trench. Shells not articulated; modern spp., largely limpet, mussel and barnacle.
	8,5–7,0 m	Coarse sand with little shell, bedded, very few boulders. In one line a few unbroken shells.
	7,0 m	Apparently platform cut in light brown aeolianite.

NORTH. M.S.L.	12,5–12,2	Black humic sand.
	12,2–10,4	Calcified sand, many shells and boulders.
	10,4–8,5	Well-rolled pebbles and some shells, mixed with sub-angular gravel, like riverine, probably reworked. Riverine gravel implies a different topography, and is probably pre-pleistocene.
	8,5	Granite-sand and rubble, apparently sterile.

In the beach there are no artefacts, and the fauna is modern. I found a pyramidical core, unrolled, in the black humic sand (N.M. 72/15).

On this stretch there is no sign of terraces at 3,5 and 1,5 m. Below the 6–9 metre terrace there is an irregular tumble of boulders to the modern shore.

At Jutten Point and South Head a narrow rock-cut terrace at 6 m is incised into the 9-metre terrace (C177–8). Two independent transgressions to these altitudes are found also on the southern coast of the Cape Province (Davies 1972). I have noticed no undoubted marine terraces between 9 m and 6 m, though other workers record altitudes of 7–8 m.

The 6-metre terrace, with rock rising behind, appears also at Bokbaai (C129; Krige 1927), Kasteelpoort (C134), Cape Columbine (C159, probably with storm-ridge up to 12 m), and at Middle Bay near Stompneus (C165); probably also, but without cliff, at Freddie se Klip near Ysterfontein (C136, about 5,5 m), Langebaan Panoramic Hotel (C150) and Slippers Bay (C170). At all these sites are planed surfaces; but I saw no shingle or calcified sand which would provide proof of a marine level. There is a 6-metre terrace along the Dieprivier between Malmesbury and Kalabaskraal.

Low-level marine beds are recorded, which from date or fauna probably belong to the 9-metre or 6-metre transgression. North of Melkbosstrand a sandy beach, up to 7,5 m, is overlain by aeolianite with mammal fossils (perhaps human kill) and M.S.A. artefacts (Hendey 1968). After the original description, a patch of shelly beach-rock was found. This must be older than the artefacts, and was dated 43200^{+2000}_{-1500} (GrN-5803; Vogel 1970); this date is regarded as a minimum. There has been no full publication. Fragments of beach-rock in a storm-ridge at Milnerton and Bloubergstrand had probably belonged to the same transgression.

On Geelbek (C138), at the south end of Langebaan Lagoon, are beds of calcareous sandstone at about 4,5 m S.L. To the south is a rise on to dune-rock; there is no cliff or evidence how far inland or to what altitude the marine beds extend. No artefacts have been found. For shell-list, see Table 1. These beds have not been dated; the submerged beds off Geelbek are at least superficially holocene and will be discussed below.

There are marine beds along the western shore of Langebaan Lagoon. South of Schrywershoek (C183), where the cliff rises from the marshy head of the lagoon, fairly hard calcified dune overlies at 2,1 m S.L. a well-cemented sand with grit, shell-fragments and a few complete shells. Species have been identified by Mr R. N. Kilburn (Table 1). There is no evidence for the original height of the beds. Their erosion into pipes suggests that they belong to the same formation as the Churchhaven-beds, which are certainly pre-holocene.

At Churchhaven, 5 km farther north, Parker (1968) describes two marine platforms at 4,2 and 1,5 m S.L. (C140–1), and separates the fauna from them. I consider that there is only one bed, into which a transgression to 1,5 m has incised as at Schrywershoek. Nor can the surface at 4,2 m be regarded as original; it is the highest exposure of an eroded

TABLE 1

SHELLS FROM THE 9-METRE AND 6-METRE LEVELS AROUND SALDANHA BAY

SITE, see key	1	2	3	4	5	6	7	8	9	10	11	B
Amblychilepas scutellum			×			×					×	
Apolymetis sp.								×				
Argobuccinum argus						×						
Aulacomya ater		×	×	×	×	×						
Balanus sp.	×	×	×		×							
Bullia annulata					×	×						
digitalis					×		×^{1}	×	×			
laevissima					×	×			×			
Burnupena cincta			×		×						×	
lagenaria		×										
limbosa			×	×								
papyracea		×	×	×								
sp.						×						
Callista cf. *lilacina*										×		
Cerithidea sp. *nov.* *Cerithium* cf. *guinaicum*					×							
Choromytilus meridionalis						×						
Clionella rosaria		×										
sinuata			×							×		
sp.							×			×		
Conus mozambicus		×	×		×							
Crassostrea sp							×^{1}					
Crepidula aculeata		×								×		
porcellana		×	×									
rugulosa					×	×						
Cymatium doliarium												×
Diodora ?parviforata						×						
Diplodonta subradiata					×							
Donax serra						×	×	×	×			
Dosinia lupinus (*africana*)						×	×			×		×
Fasciolaria lugubris										×		
Fissurella ?glarea					×							
mutabilis					×	×						
Fusinus ocelliferus		×										
Gastrana abildgaardiana											×	
?matadoa								×				
Gibbula capensis			×									
Haliotis midae					×							
Helcion pectunculus			×									
sp.	×											
Kraussina rubra				×								
Littorina knysnaensis					×							
Loripes liratula							×			×		
Lutraria lutraria					×							
sp.						×						
Mactra glabrata						×	×			×		
Marginella capensis			×							×		
Mitra aerumnosa			×									
Mytilid									×			
Nassarius capensis					×							
?desmouloides										×		
plicatellus							×			×		
scopularcus					×							
speciosus				×	×		×^{1}			×		
Natica genuana										×		
sp.	×											
Ostrea atherstonei						?	×				×	
sp.									×	×		
Oxystele tigrina							×					
variegata							×					

SITE, see key	1	2	3	4	5	6	7	8	9	10	11	B
Patella argenvillei										×		
barbara			×		×	×						
cochlear			×									
compressa		×		×								
granatina			×			×						
granularis				×		×						
sp.		×							×			
Perna perna					×							
Petricola sp. nov.					×							
Purpura sp. nov.					×							
Rissoid sp.							×					
Siphonaria capensis							×					
Solariella sp.					×							
Solen capensis							×			×		
Tapes corrugatus		×	×				×				×	
Tapes deshayesii				×								
sp.										×		
Tellina gilchristi							$\times^{1}$					
madagascariensis							$\times^{1}$			×		
trilatera						×				×		
Thais cingulata		×	×									
dubia							×					
squamosa		×	×			×						
Tivela compressa					×							
Tritonalia purpuroides			×	×							×	
Trochus sp.		×										
Turbo cidaris					×							
? sarmaticus		×										
Turritella capensis										×	×	
carinifera			×				×			×		
Venerupis corrugatus						×						
Venus verrucosa							×			×		

N.B. Obsolete shell-names have been kindly corrected by Mr Kilburn.

SITE-KEY

1. JUTTEN POINT, site C180, 33°06′S 17°58′E. Coll. Davies 1970, id. Kilburn. Beach-rock on rock-cut terrace at 9+ m.
2. NOORDBAAIPUNT, site C188, 33°02′S 17°56′E. Coll. and id. Krige. Platform at 6 m with no cliff exposed.
3. HOETJESPUNT, south face, 33°02′S 17°57′E, site C156. Recorded and id. Krige (1927) and Haughton (1931: 33–4). Terrace at 6,5 m. Krige gives two spp. not in the list copied by Barnard (1962) from Haughton.
4. HOETJESPUNT, around north and west sides of Smithswinkel Bay, site C155, 33°01′S 17°57′E. Recorded and id. Haughton (1931: 33). Shell-bed on rock-terrace at 4½–7½ m (Parker 1968) or −1 – +9 m (Du Toit, 1917). Now apparently masked save at extreme south end behind Seaharvest Factory (C186).
5. LANGEBAAN, beside the road a little north of the village, site C152, 33°05′S 18°02′E. Coll. Davies and Tankard 1972, id. Kilburn and Tankard; a very scanty list in Haughton (1931). Shelly limestone on platform at 9,5 m; Haughton gives 6 m, if his is the same site. Fauna mainly warm-water, 3 cold-water spp.; 4 spp. extinct.
6. LANGEBAAN, below and north of 5, site C191, 33°04′S 18°02′E. Coll. Davies, id. Kilburn. Uncemented beach-deposit at about 4,5 m. *Diodora parviforata,* if correctly identified, is a giant specimen compared to those living on the Atlantic coast today.
7. CHURCHHAVEN, site C140, 33°10′S 18°04′E. Coll. Davies 1970, id. Kilburn; species identified by Parker (1968) but not by Kilburn marked x^{1}. Bed eroded at 4,2 m, original altitude may have been 9 m.
8. SCHRYWERSHOEK, site C183, 33°12′S 18°06′E. Coll. Davies 1971, id. Kilburn. Beds probably identical with 7 but surviving only to 2,1 m.
9. GEELBEK, about 300 m east of 10 on new road, site C187, 33°12′S 18°09′E. Coll. Davies 1972, id. Kilburn. Shells in sand at about 5 m. Though altitude is close to that of 10, the uncemented white sand and the difference in fauna indicate that the two deposits belong to different transgressions, 9 is probably the older, and may be older than the dune-cordon forming the Langebaan Peninsula, when the lagoon would be open water.

10. GEELBEK, site C138, 33°12'S 18°08'E. Id. independently by Krige (1927: 76–9) and Haughton (1931, p. 34); Krige gives a longer list lacking only two of Haughton's spp. A few coll. Davies, id. Kilburn. Fauna estuarine and rocky. Calcified beds up to 4,5 m. Site now buried in sand; I have seen fragments of the rock, but did not collect.
11. GEELBEK, site C139, 33°12'S 18°07'E. Coll. and id. Haughton (1931: 34). Submerged beds at south end of Langebaan Lagoon, much lower than 10, and in view of a radiocarbon-date (GrN-5878) may be entirely holocene. See p 729.

B. SALDANHA BAY. Shells in Barnard's list (1962) which he did not get from Haughton or Krige, so presumably his own identifications from other collections. He gives no localities. He says that he drew on Wybergh as well as Haughton; but Wybergh gives no identifications.

surface, overlain unconformably by aeolianite. The original altitude is unknown and could well have been 9 m. A (minimal) date for the main bed is 48500^{+3600}_{-2900} (Pta-096; Vogel & Marais 1971: 382).

The main bed is hard gritty shelly sand with a few lines of shells. It was deposited in quiet water, as some *Dosinia* in it are upright and in articulation. Its present surface is formed of nodules of calcified sand with numerous uncemented shells. The bed has eroded into pipes.

As I consider that no independent fauna can be identified from the 1,5-metre terrace, I give all the fauna together (Table 1). There is much difference in the lists by Kilburn and by Parker, who is not a qualified malacologist.

There must have been a similar bed, 0,6–0,9 m thick at 6–9 m S.L., at Oude Pos (Rogers *ap.* Du Toit 1917: 11). The area is now closed.

In the bay just west of Hugos Pos a well reveals aeolianite at about −2 m S.L. In the upcast are fragments of beach-rock which I could not locate *in situ* (C145). Behind the well a narrow coastal plain rises to about +3,5 m and abuts against a steep scarp of aeolianite. At the west end of the bay the sea is now planing a yellow mudstone containing rock-fragments. Whether this terrestrial deposit is quaternary is uncertain. The aeolianite of the scarp and in the well may belong to the last eustatic low, planed by the first holocene transgression. If the beach-rock is beneath the dune, it could be of the same stage as Geelbek and Churchhaven; if it overlies it, it will have formed in the holocene transgression. Beach-rock similarly excavated from a well at perhaps below modern S.L. is to be seen at the south-west corner of the bay east of Britannia Point.

To the same stage belong the beds on both banks of the Berg River estuary at Vlaminke Vlei and Velddrif (fig. 2); they will be described in the next section, under Table 2.

The high throw on this exposed coast makes it difficult to assign storm-ridges to their correct stages. Parker claims that the beach-ridge at North Head is modern; this is certainly wrong (see above, p. 724). The most accessible and best preserved sequence is at South Head and Jutten Point. I have mentioned terraces with cliff-bases at 9 m and 6 m; on the east side of Jutten Point there are traces of a rock-cut terrace also at 3,5 m (C176). There are two principal storm-ridges: one to 11,5 m (C177–8), with large boulders and some *Patella*, on the outer edge of the 9-metre terrace and supporting the lighthouse on South Head; the other at 6,9 m on South Head and 6,0 m on Jutten Point (C175–6), composed of boulders and many broken shells, mostly *Patella* and *Mytilid*, and heavily vegetated. A sample of *Patella argenvillei* from this rampart on South Head gave a date of 2070 ± 50

(Pta-461); so it apparently belongs to the second holocene transgression, the 1,5-metre terrace at Churchhaven. The modern fetch of storm-spray is about 4 m.

This very recent date for an exposed storm-ridge at over 6 m makes one hesitate to assign other ramparts along this coast to a pleistocene transgression. I noted beach-ridges at 6 m or less:

Britannia Point, at 6 m beneath modern dune, C162; at latest early holocene, as Krige (1927: 42) recorded a ridge with crest at 2,4 m;
Cape Columbine, at 4,8 m, C158;
Duminypunt, at 4,5 m, C157 (Krige);
Kasteelpoort, at 4,2 m, C135.

Ramparts above 6 m may be pleistocene, depending on the exposure; but there are from them no significant faunal reports or carbon-dates. Such are:

deposits of broken shell on a well-smoothed terrace at 7,5 m round the point just west of Hugos Pos, C143;
shell-ridge at 7,0 m in Kreeftebaai, C142 (Parker 1968), probably not the source of the dated sample Pta–094 (see above, p. 723);
shell-ridges up to 7,8 m in Skulpbaai south of Bokpunt, C125 (Haughton 1933: 49).

Along this coast two holocene sea-levels can be identified from rock-cut terraces and carbon-dates. At the east point of the harbour at Bokbaai, beneath a terrace visible at 5,4 m without cliff, is another with cliff-base at 3,9 m (C130–1; both seen by Krige), and probably a third with cliff at 1,8 m (C132). Haughton (1933) records the 3,9-metre terrace also at Buffelsrivierstrand (C127). The exposures at Bloubergstrand (C124) are less convincing, being poorly preserved in the steeply dipping shales and perhaps concealed by modern buildings. Haughton records a terrace at 2,4–3,6 m; at present the highest rock-exposure at the point is about 3,5 m, but is not necessarily part of a terrace. There is certainly one at 1,8 m, and a second incised into it at 0,9 m M.S.L. None of these levels is distinguishable at Ysterfontein; but there has been much quarrying round the harbour.

Dune masks the whole outer coast of the Langebaan Peninsula. I have mentioned the date (Pta-461) for the storm-ridge at South Head. At Hugos Pos (C144) and Rietbaai (C147) there are well-marked platforms and cliffs at 3,5 m. Around Saldanha Bay are traces of both holocene transgressions. A small promontory to 4,2 m at Kliphoek is probably the remains of a terrace. There are terraces at 1,5 m at Langebaan (C151) and incised into marine beds at Churchhaven (C141) and Schrywershoek. The shell-beds in shallow water at Geelbek (C139) have yielded a date of 6410 ± 45 (GrN-5878), so probably belong to the older holocene transgression; but they may overlie older beds which would correlate with Churchhaven. The Geelbek beds appear up to +2 m at the gate between Geelbek and Schrywershoek, at the extreme south-west corner of the lagoon. Haughton (1931: 34) lists shells from the submerged beds (see Table 1) and remarks that *Ostrea atherstonei* is not now found alive in the lagoon. From a sample which I collected just above S.L. at the gate Mr Kilburn has identified *Clionella* sp., *Dosinia lupinus* (= *africana*), *Loripes liratula*, *Tellina trilatera* and *Venus verrucosa*.

Although there are holocene storm-ridges at the mouth of Saldanha Bay and farther north, I have not found low-level marine terraces or beach-cordons outside St. Helena Bay (fig. 3 upper). They may be concealed beneath beach-sand and redistributed by strong winds.

The high beach-ridges continue round Shell Bay (C163–4) and St. Helena Bay; they are recorded by Krige at 2,4 and 4,5 m. In St. Helena Bay are rock-terraces at 1,5 m (Middle Bay, C166; east of Sandy Bay, C168; Soldatepos, C169; west side of Slippers Bay, C172); and at 3,0–3,6 m at Sandy Bay and Slippers Bay (C167, C171).

BERG RIVER TO OLIFANTS RIVER

North of the Berg River the coast is fairly straight. A coastal plain, nowhere very wide, rises gently to a steep scarp which bounds the inland plateau. Except where the scarp is close to the coast, as at Elands Bay and Olifants mouth, it is not a marine cliff as it stands. The altitude of its base varies with its distance from the coast, about 160 m south of R. Olifants, 50 m near Lambert's Bay and 100 m towards the Berg River. Along most of this stretch the whole coastal plain could have been overrun by the highest pleistocene transgressions; excavation through its deep cover of sands and terrestrial wash might well reveal pleistocene beaches to a high level, as it has in Namaqualand.

South of the Berg River there is little evidence for a 30-metre S.L.; but it might well be identified in large excavations (cp. Hendey 1970*b*). It appears where the T.M.S. reaches the coast. It is not distinguishable on the cliffs at Elands Bay or in the small estuaries to the north; but it is recognizable on the wide terrace north of Doringbaai. This terrace, several hundred metres wide and very level, is best seen above Pikkersbaai (W32) just south of Strandfontein. No cliff is exposed, but the inner edge is a steep slope of calcified terrestrial material which probably masks a cliff, whose base will have been at or just above 30 m. The terrace is overlain by a scatter of pebbles, disturbed by a road but apparently 3–5 m thick. I found no artefacts or molluscs.

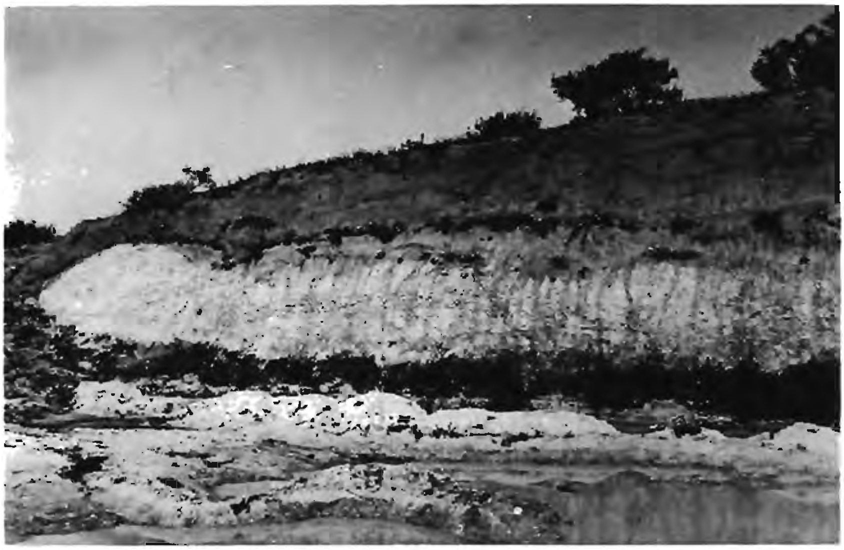
Haughton (1931) describes the planed rock-surface as extending for 20 km south to Donkin's Bay and dipping slowly. This terrace is not continuously traceable. Haughton may have combined two terraces; the platform at 18 m at Bamboesbaai and at 14 m at Kanon (W25) just north of Donkin's Bay probably belongs to the lower transgression. I measured the cliff at the north end of Doringbaai as 24 m; but, as it carries no shells, it may be an erosion-surface.

Haughton describes a shelly deposit about 3 m thick on the terrace, apparently near Doringbaai. His faunal list suits that of Carrington's 23-metre terrace in Namaqualand, especially *Donax rogersi* which Carrington regards as the type-species of that transgression (Carrington & Kensley 1969).

Beside a garage down a lane from Strandfontein Hotel I saw in 1953 and in 1971 a marine deposit (W37; Davies & Walsh 1955):

at 30 m, beneath calcified sand, surface with unrolled Sangoan
rather sub-angular pebbles
whitish sand
layers of ferruginized gravel and grits
rock-platform not exposed.

This may have been at the head of a cove. The altitude does not agree with that of the rock-terrace on the other side of Pikkersbaai, but corresponds with what is probably the same terrace at The Point (W38–9), just north of R. Olifants (platform > 24 m, beach-surface > 27 m), and probably with the Olifants Canal Gravels.



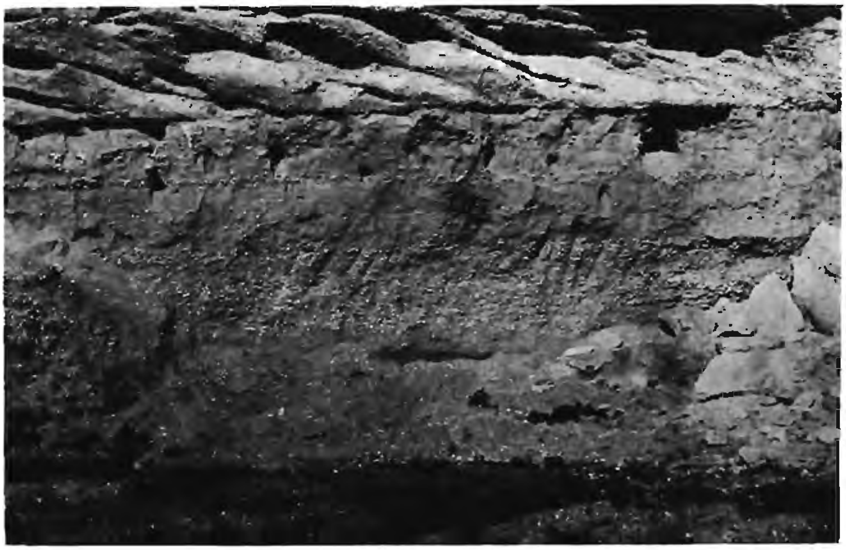
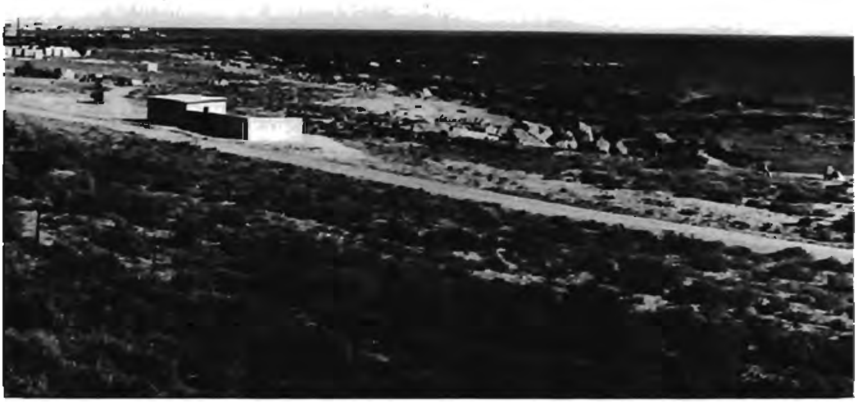


Figure 2
Upper: Vlaminke Vlei C173, 6-metre beds at mouth of Berg River.
Lower: Velddrif W2, 6,6-metre beds at mouth of Berg River, probably marine.



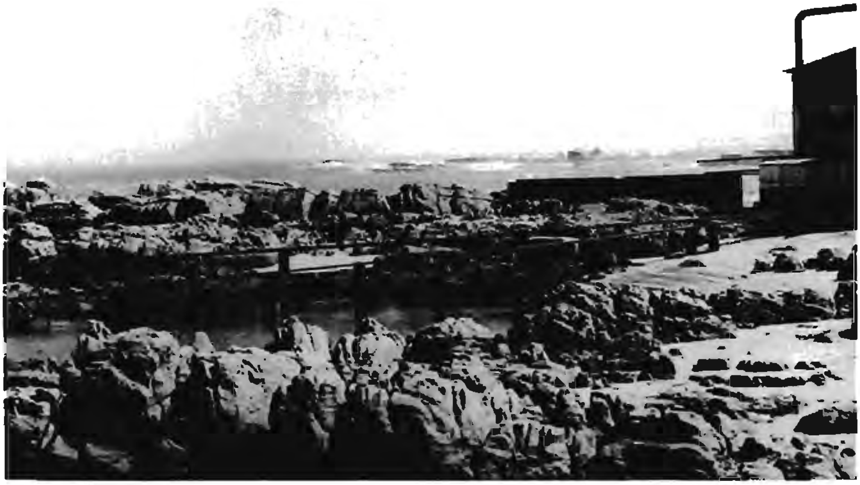


Figure 3.
Upper: St. Helena Bay C167–8, terraces at 3,3 and 1,8 m.
Lower: Lambert's Bay and Bird Island, W19 and W23, terraces at 6,0 and 3,6 m.

I have mentioned estuarine gravelly beds at 18 m on the south bank of the Berg River. A deep fine sand, containing coarser grains and pebbles but without shells, is exposed in a pit on the north bank at the east end of Velddrif, above De Plaat (W1). Its surface is at 18 m, its base is not exposed. It may be a lagoon-deposit.

There is perhaps a rock-cut platform at 18 m above the farm Verlorevlei. It is not visible on the coast on Baboon Point.

The top of Lambert's Bay village is a level surface at about 18 m (W22). Large rounded quartzite boulders on it, though not *in situ*, appear to have been excavated from the dune-overlay and to mark the neighbourhood of a cliff which is not exposed.

Southward from Strandfontein there is almost certainly a rock-cut terrace at 18 m below the 30-metre one. Its cliff-base can be seen on both sides of Pikkersbaai cove (W33). Bruinpunt, the southern headland of Bamboesbaai, is a rock-terrace at 15 m, rising gently inland (W30); the cliff is masked. It carries pebbles and calcified beds of cold-water shells beneath red dune. On the gravel I found unrolled M.S.A. artefacts, disc-cores and a triangular point. At Kanon, north of Donkin's Bay, is a wide platform at 14–15 m S.L. (W25) covered inland by dune without cliff-exposure; this must be Haughton's 15–18 metre terrace at Donkin's Bay, where there are no high rocks. On this terrace I saw no shells or pebbles.

Thick shell-beds are exposed at many points between Berg River and Lambert's Bay. I consider that all belong to the same transgression, to 8 or 9 m. The maximum altitude of the exposures is 6,6m M.S.L.; some, such as Steenbokfontein, are lower. Some appear to be beach-ridges lower than the cliff-bases, which are not exposed and may not survive; some are lagoon-bottom deposits. The only ridges across estuaries are Velddrif (W2) and Wadrif (W118; surface of beds just exposed along the road). I have tabulated all the fauna together in Table 2. All the shells are of common west coast species; there are no warm-water forms.

Rock-cut terraces at Elands Bay seem to belong to the same stage as the littoral cordon. There may be a terrace at 6 m (W9; Krige 1927) round Baboon Point. At Danielsdrif a short way up the valley were well-rolled pebbles in a gravel 1 m thick at 7½ m S.L. (W12). There are remains of a surface at about 6 m on a stack at Malkopbaaipunt (Lambert's Bay; W19) and on Bird Island (fig. 3 lower).

As most of the late-pleistocene evidence along this coast consists of shell-beds whose exact altitude in relation to contemporary M.S.L. is uncertain, we cannot tell whether there were one or two transgressions. Surfaces of stacks without cliff-bases also are unsatisfactory. At Kanon (W26) a thick bed of marine pebbles and sand is banked against the cliff up to 12 m. Krige claims a rock-cut terrace at Doringbaai at 7½ m, Haughton at 7½–9 m. At the north end of the village (W28), sand pebbles and shells, including *Patella*, are banked against a cliff, probably to about 9 m, but mining has made the altitude uncertain. South of the village the promontories Vaalpunt and Die Hospitaal have shoulders at 9 m, with slight rise in the centre; they may have been small islands in the ? 9-metre sea. There are probably traces of a terrace at 9 m, again insulated from the main cliff, at the point of Strandfontein (W34).

As much of this coast is sandy, evidence is scarce for low-level transgressions. I have mentioned the 3,9-metre terrace incised into the littoral cordon at Dwarskersbos-Soverby

TABLE 2

VELDDRIF AREA, SHELLS FROM 9-METRE BEDS

SITE, see key	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Afrocominella capensis					×			×								
Amblychilepas scutellum			×													
Anadara natalensis	?															
Argobuccinum argus	×		×		×	×		×	×		×		×	×		
Aulacomya ater	×			×			×							×		
Bullia digitalis					×		×	×	×						×	
laevissima		?	×	×	×	×	×	×	×	×						
pura	?															
rhodostoma	?					?	×									
Burnupena cincta	×		×		×		×		×					×		
lagenaria														×		
papyracea	×				×		×	×	×					×	×	
Calyptraea chinensis					×											
Choromytilus meridionalis					×	×	×	×	×	×	×			×	×	×
Clionella sinuata			×		×										×	
Crepidula aculeata		×		×	×	×			×	×						
? rugulosa			×	×	×		×	×	×	×				×	×	
Cymatium doliarium	×					?										
Donax serra	×							×								
Dosinia lupinus										×		×	×			×
Fasciolaria lugubris								×	×							
Fusinus ocelliferus					×		×	×	×	×						
Gastrana abildgaardiana													×			
Glycimeris queketti	?															
Helcion pectunculus														×	×	
pruinosus	×															
Lutraria lutraria			×	×	×	×	×	×	×	×	×					
oblonga	?															
Macoma ordinaria					×											×
Marginella capensis					×			×								
Nassarius analogicus					×											
capensis						×										
kochianus					×											
muiri					×											
plicatellus					×		×									
scopularcus					×				×							
speciosus				×					×							
Natica queketti	?															
saldontiana	×				×		×									
Ocenebra purpuroides					×			×								
Oxystele tigrina														×		
variegata														×		
Patella argenvillei														×	×	
barbara											×			×		
compressa	×	×			×	×										
granatina														×	×	
granularis														×		
Scissodesma spengleri	?	×						×								
Solen capensis					×											
Tapes corrugatus		×	×	×	×	×	×	×	×	×	×			×	×	
Tellina trilatera	×											×	×			
Thais cingulata					×		×							×	×	
squamosa	×		×		×	×	×	×	×	×				×	×	
Tivela compressa									×							
Turritella capensis							×									
Venerupis corrugatus																×
Venus verrucosa		×			×		×		×				×			
Balanus, very large											×					

KEY TO SITES IN TABLE 2

1. VELDDRIF, site W2, 32°46′50″S 18°09′40″E. Id. Krige (1927), copied by Barnard (1962) with corrections and queries on some of Krige's identifications. The beds extend all along the town as a bank of shelly calcified sands up to 6,6 m S.L. Towards the east end of the town the Berg River flows above sea-level, so the crest of the bank is not more than 5 m above it. There are small exposures in the town and the bank is traceable east of it near Ouwerf and De Plaat. The main exposure is a large quarry just west of the town (fig. 2 lower). Three strata with horizontal surfaces are distinguishable:

A. From the quarry-floor at 2,7 m to 4,2 m S.L. Packed shell-fragments, slightly calcified but not cemented, with little sand and a few pebbles. Probably a thanatocenosis in fairly still water.

B. From 4,2 to 5,4 m S.L., soft whitish sand with very few pebbles. Many bivalves articulated. A few small and discontinuous lines of fragmentary shells. Close to the surface of this stratum are two lines of brown sand about 5 mm thick. They do not seem to mark a local emergence, but may be due to seepage from a large adjoining root-hole which is later than stratum C.

C. Concreted shell-fragments with little sand but with small pebbles. At base a hard horizontal layer, overlain by current-bedded sands dipping northward about 10°. No articulated bivalves. Probably deposited at the start of a marine regression, when the estuary may have been tidal but there was much scour.

The surface of C is slightly ravined. On it are now 30–60 cm of red wind-blown sand with terrestrial shells.

2 and 3. VLAMINKE VLEI, at the bridge on south bank, site C173, 32°47′55″S 18°10′10″E. Coll. Davies: 2 1953, id. Barnard; 3 1969, id. Kilburn. Exposure at the crossroads (fig. 2 upper). The terrace was about 6 m above the river, in 1969 its surface was at 5,7 m, but had been slightly bulldozed. Eastward the terrace is composed partly of small sub-angular quartz gravel interbedded with sand. At the pit was calcified shell and a few pebbles, formerly overlain by 1½–2½ m of blown sand. Slightly upstream on the gravel lay an unrolled conical core (N.M. 73/53). Downstream, on a silcrete cliff at 4,5 m which must have been part of the terrace, were two pyramidical cores embedded, and silcrete flakes and a marine pebble on the surface.

4–9. VELDDRIF, as column 1. 4 and 6 coll. Davies 1953, id. Barnard; 4 from stratum C, 6 from A and B combined. The others, coll. Davies 1969, id. Kilburn; 5 from stratum C, 7 from B, 8 from A, 9 a general mixed collection.

The coastal road north from Velddrif and Laaiplek to Dwarskersbos runs along a flat-topped bank at 6 m S.L., which must be the continuation of the littoral cordon from the beds of columns 1–9. There are few exposures.

10. LAAIPLEK, just west of the road and south of pt. 26, about 2 km north of the town, site W3, 32°45′35″S 18°09′55″E. Coll. Davies 1969, id. Kilburn. The surface of the shell-bed is at 6,0–6,3 m; down to 4,2 m was a single stratum without unconformity; *N.B.* no *Patella* on the open beach. Quarries on the eastern scarp of the cordon down to 2 m S.L. (facing site W4) revealed stratification corresponding to that at Velddrif. Up to 5,1 m is packed shell with a few thin ferruginized layers. From 5,1 to 6,6 m are stratified varves of black and white sand with a few laid shells. The current-bedded stratum C is seen only on the east wall of the quarry, where the cordon dips sharply into a depression at not more than 3 m S.L., filled with brownish sand but very few shells; this may be the bed of a vlei which at the start of the regression had drained into the estuary. The 6-metre surface recurs east of the depression, whose floor rises north, so that 6 km north of Laaiplek it is no longer distinguishable.

11. DWARSKERSBOS-SOVERBY, sites W5 and W6, 32°42′50″S 18°12′10″E. Coll. Davies 1969, id. Kilburn. The 6-metre beach is east of the road. It is 2 m thick, and rests on red sandy clay, perhaps decomposed shale. There may be traces of a cliff at the back; but the higher surface has been eroded by a valley parallel to the coast, east of which the surface is at >12 m. The collection was made from shallow pits in a 3,9-metre terrace incised into the 6-metre cordon. Besides shells there were many shale-slabs, and some of the shells are rupicolous. This is the only pit on this coast which yielded very large *Balanus*.

The 6-metre beach is again exposed at Tierheuwel (site W7, 32°40′45″S 18°15′45″E) with calcrete-cemented shells; no collection was made. This was probably part of the littoral cordon.

Though there is a prominent modern dune-cordon backed by vleis all the way to Baboon Point, the only exposure of the old beach-cordon is 16. The shell-beds reappear on the south bank of Verlorevlei.

12 and 13. VERLOREVLEI, site W14, 32°19′25″ and 32″S, 18°21′45″ and 22′05″E. Coll. Davies 1969, id. Kilburn. At the eastern pit a rock-terrace dips from cliff-base at 6,3 m M.S.L. towards the vlei and plunges into what seems to be a deep trench. On the terrace are some pebbles and patches of packed shell, mostly *Dosinia*. A few slightly rolled broken pebbles could not be accepted as artefacts. In the western pit are a few shells in whitish sand, some articulated; some pebbles are cemented to the cliff. On the overlying talus-slopes were crude quartz microliths. Verlorevlei looks like a eustatically cut gorge; but as a rock-bar closes its present mouth, it must be assumed that there is a fossil mouth beneath the dunes.

14. MALKOPPAN, site W17, 32°07′40″S 18°18′28″E. Coll. Davies 1969, id. Kilburn. In several pits packed shells and sand up to 6 m S.L., heavily calcified, overlie boulders on a gullied rock-platform at 3,3–3,9 m S.L. The rock forms low promontories; between them the beach formed a littoral cordon perhaps backing on a fossil lagoon.

15. STEENBOKFONTEIN, site W16, 30°10′20″S 18°18′40″E. Coll. Davies 1969 and 1971, id. Kilburn. No rock-terrace is visible on Grootrif. The exposure was in a small pit just north of the homestead, into what must have been well down a shelly beach on an exposed shore, for the shells are well pounded. Beneath 30 cm of calcrete is at least 1 m of shells. It was difficult to measure the altitude across a wide modern dune. Water began to seep in at 80 cm below surface, and I think that the bed is very close to sea-level. A pleistocene date is indicated by Pta–464, on a sample of *Burnupena papyracea*, 39300 ± 1600.
16. VERLOREN VLEI, site W116 on the outer coast west of Put se Kop, 32°21′10″–40″S 18°20′00″–20″E. Coll. Davies 1972, id. Kilburn. Beneath sterile calcified sand, a bed of sand containing a few unarticulated shells, surface about 6 m S.L., thickness unknown.

(W6). There are rock-cut terraces with cliffs at 3,6 m at Baboon Point (W10), probably at Swansea (W13) at the mouth of Verlorevlei, at Malkopbaaipunt (W20, fig. 3 lower) and Bird Island (W23; Krige) and perhaps at Strandfontein Pikkersbaai (W35: storm ridge at 4,2 m, cave with floor lower than 4,2 m); at 1,5 m at Baboon Point (W11), Malkopbaaipunt (W21), Doringbaai (W29) and Strandfontein (W36). The storm-beach at 4,5 m at Bruinpunt, Bamboesbaai (W31), may belong to the 1,5-metre sea or even be modern. Intertidal platforms at Baboon Point (W8, 0,3 m), Malkoppan (W18, 0,6 m), Malkopbaaipunt (0 m) and Donkin's Bay (W24, 0,6 m, perhaps extending far under the dunes) are covered by modern beach and cannot be placed in the sequence. The low platform outside Baboon Point (W117) is much gullied but is not being eroded today; it may therefore be an old feature exhumed.

THE OLIFANTS RIVER TERRACES

The rarity of satisfactory coastal evidence compels us to consider the well-preserved gravels of R. Olifants below Vredendal, which contain artefacts so seldom found in the beaches of this coast. The Olifants is as important a river as the Berg River, but flows in a narrow and steep-sided valley right to its mouth through a gorge through the coastal hills. Below Clanwilliam (about 90 m S.L.) the thalweg is gently sloping, with one or two narrows and an important nickpoint at Bulshoek (fall of > 20 m). Only below Vredendal does the valley-bottom become sufficiently low and level for terrace-gravels to be correlated with marine platforms, and the river is tidal only close to the mouth. In 1953 I surveyed the terraces with Mr R. C. Walsh (Davies & Walsh 1955), and again in 1971 when much of what had been visible had disappeared owing to the development of the irrigation settlement. I have drawn also on Mabbutt's account (1955).

The principal terrace-gravel is the Canal Gravels, which first appear, at 42 m above river and nearly 61 m S.L., above the cliff at the narrows in Bakleiplaas A below Vredendal. The gravel is 6 m thick and is formed of rounded and sub-angular medium-sized pebbles. I found no rolled artefacts, a few unrolled pieces are probably Sangoan. At the time of the Canal Gravels, these narrows must have been a nickpoint; for at Melkboom 2½ km downstream the gravel reappears on the scarp above the furrow, 12 m thick and resting on a rock-terrace at 24–7 m above river and about 37 m S.L. In 1953 I saw bedded gravels and grits capped by 3 m of sand. Near the base of the gravels were found (N.M. 15/53) five very rolled pieces, three probably hand-axes, one chopper and one rounded scraper (fig. 4); on them was unrolled Sangoan.

The Canal Gravels disappear for some distance below Melkboom and reappear just west of Koekenaap station at 24–30 m S.L. and very little less above river. They must have been deposited on the outer part of the Silwereik promontory, where there is a spot-height

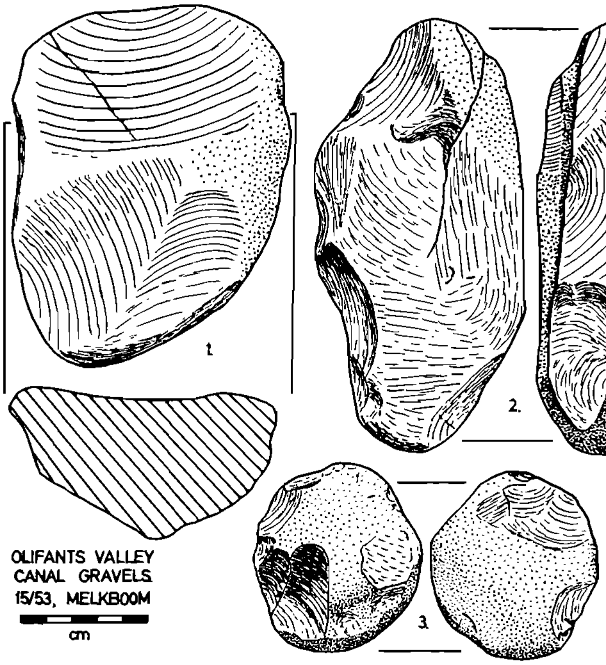
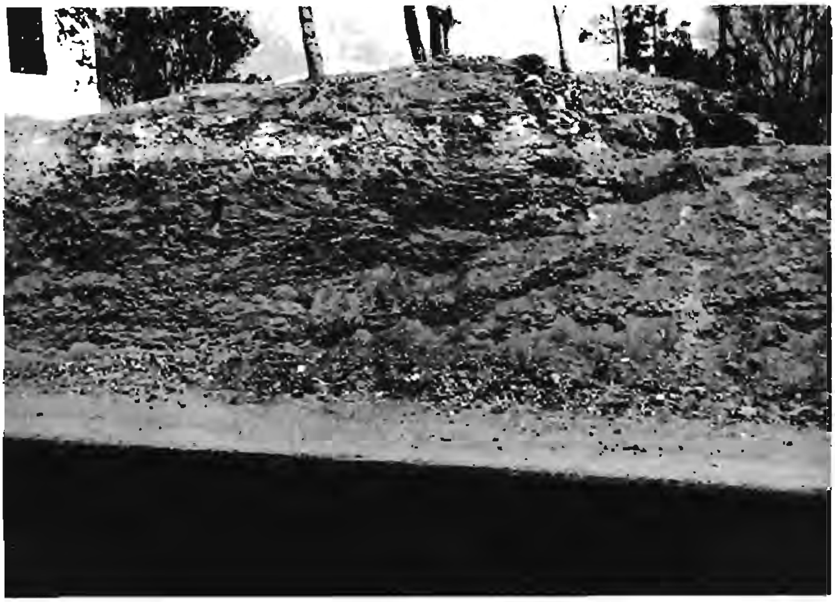


Figure 4.

of 27,7 m (91 ft), but have been removed by erosion. At Koekenaap they are best exposed on the road west from the station, as cross-bedded layers of small pebbles and sand (fig. 5 upper), probably laid down by a fast current. Near Silwereik were found two rolled pieces, a pick and an end-scraper (N.M. 30/53, fig. 6 3–4), and a scatter of unrolled artefacts, some Acheulian. On the calcified dune above the gravels near the station, now mainly built over, was an unrolled assemblage which seems Late Sangoan (N.M. 38/53; Davies 1955).

The best exposure of the Canal Gravels is west of Platzkraal (W42) on the cliff overlooking from the west the lowest part of the plain (Davies & Walsh 1955, s.v. Voorbeeld West; the name Platzkraal is more correct). The top of the cliff is 21 m above the vlei in the plain, which is at the same level as the river and little above S.L. The cliff is capped by 12 m of ill-assorted sub-angular and rounded medium and small pebbles mixed with grits and sands and not properly bedded; these gravels are heavily calcified near surface and are overlain by consolidated red dune. They may be seen also on the road north of the cliff and at the road-junction just east of Platzkraal homestead. They appear to be a riverine deposit in a wide swamp, whose surface at 33 m relates it to the 30–33 metre shoreline.

In these gravels I found in 1971 heavily rolled artefacts (N.M. 71/38 and 71/39), a gouge-like cleaver (fig. 6 2), perhaps a hand-axe (fig. 6 1) and three choppers. On its surface were five unrolled hand-axes, rather crude and perhaps Middle Acheulian, and two miniature hand-axes which may be Sangoan (N.M. 28/53; Davies 1955). On the talus at the foot of the cliff was one Sangoan piece which may have slipped down, otherwise nothing older than Late M.S.A.



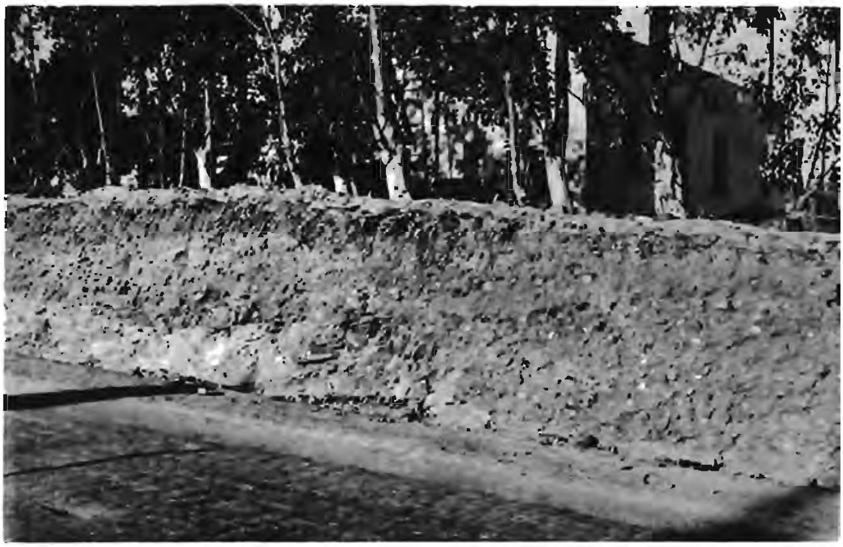


Figure 5.
Upper: Cross-bedded Canal Gravels at 24–30 m S.L., below Koekenaap station.
Lower: Vredendal, 9-metre terrace and gravels.

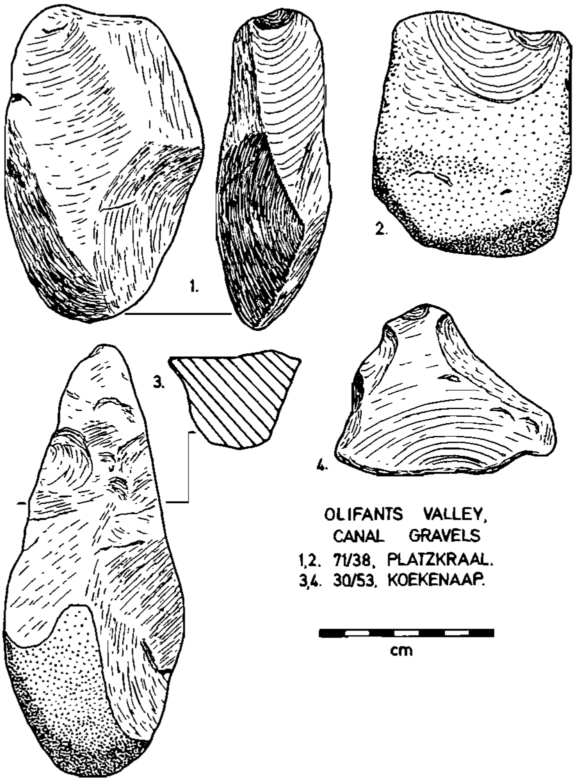


Figure 6.

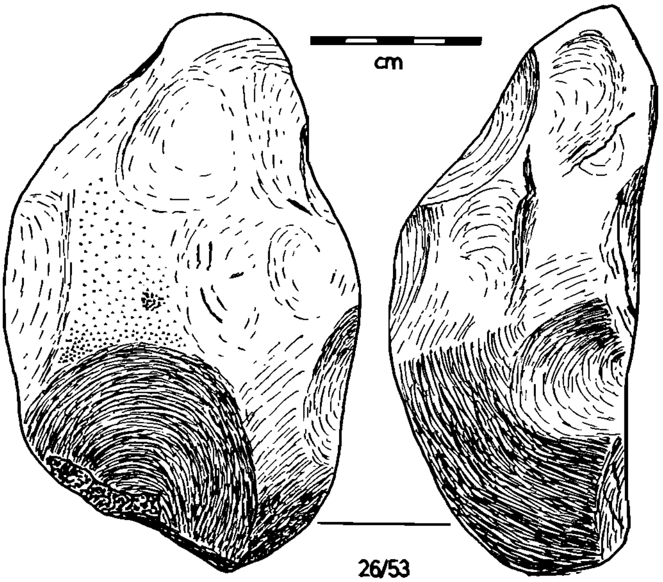
Not far below Melkboom I saw in 1953 small exposures of a steeply dipping gravel which apparently diverged from the Canal Gravels just below the nickpoint. It was about 6 m thick and in composition resembled the Canal Gravels. It was visible at few places. It was near the present valley-floor at Vlermuisklip and probably plunged into a trench incised during the eustatic low of the penultimate glaciation. I was told that in the Platzkraal basin a boring had reached bedrock at about —75 m. No artefacts were found in this gravel by which to correlate it with the Canal Gravels. The entrenchment must have penetrated farther upstream during the last glaciation and after the formation of the 9-metre terrace, for Mabbutt reports that rock was not reached at —13 m S.L. above Klawer.

If the Canal Gravels are to be correlated with the 30-metre S.L., as from contained artefacts seems reasonable, the 18-metre shoreline must be contemporary with a wide rock-terrace carrying a scatter of pebbles at about 15 m above river on both banks near Ebenhaeser Mission below Platzkraal (W43). Scattered Sangoan pieces were found on it.

A terrace at 9 m above river can be traced from Vredendal. It probably belongs to the 9-metre S.L., perhaps also to the 18-metre if the two were not separated by a long interval and the adjustment of the thalweg had no time to penetrate far from the mouth. In 1953, on the north bank at Vredendal bridge, a rock-terrace at 9 m was capped by at least 1½ m of bedded gravels, mostly rounded and sub-angular quartzite (fig. 5 lower); almost all had been removed by 1971. I found possible rolled pebble-choppers and one large unrolled flake. Near Bakleiplaas A I saw in 1953 at 9 m above river an accumulation of pebbles and hillwash; it was not on a terrace, but must have formed when the river flowed not far above its present level. It was upstream from Melkboom; so after the entrenchment to that point the sea will have risen eustatically, and continued headward incision through the Bakleiplaas narrows will have been to a river-level not far above present. In this gravel I found (N.M. 16/53) a small hand-axe and unrolled flakes and tools, probably Sangoan (Davies, 1955).

Below Platzkraal the river is incised into a flood-plain 3–3½ m high, probably of holocene date. Behind it a bank of greenish riverine sandy muds is exposed beneath dune up to 6 m above river (W44). On the bank I saw a thin scatter of pebbles, sharp pieces of quartz, broken *Patella* and a few gasteropods (N.M. 71/37). One thumbnail-scraper and two rough crescents appear to be Wilton, and a very few Wilton pieces were found on the dune behind. One large silcrete flake used as a scraper may be M.S.A. These pieces are unrolled, and provide a *terminus ante quem* for the greenish muds.

There are traces of a terrace-gravel higher than the Canal Gravels. Mabbutt (1955) claims two terraces, at 60 and 45 m; but I nowhere identified both on the same traverse, and think that there may be only one, dipping more steeply than the present thalweg. In 1953 I saw about 4½ km from Vredendal towards Vanrhynsdorp a terrace with small and medium pebbles at over 50 m above river (Davies, 1955). There were many unrolled artefacts, probably Sangoan, but nothing rolled. The gravel at Bakleiplaas A could, on altitude,



MONTE VENDA, VLERMUISKLIP: 45-METRE GRAVEL.

Figure 7.

belong to this terrace. The Canal Gravels may have diverged from the higher terrace at the nickpoint. There are however scattered quartzite pebbles, presumably from a higher gravel, above the main gravel; these are unlikely to have been humanly transported, as the Sangoan is made on silcrete. Below the nickpoint there are two distinct terraces. A section of the upper gravel is to be seen on the road above Monte Venda, Vlermuisklip, at about 45 m above river and 52 m S.L. In it I found (N.M. 26/53) three very rolled choppers (one resharpened as a small cleaver) and two picks (fig. 7). The gravel is overlain by red dune on which occur Sangoan pieces. A scatter of gravel at over 45 m S.L. near the road where it crosses the Silwereik promontory (W41) probably comes from the same terrace. Unrolled cordiform hand-axes and pieces which look Sangoan were found; there were no rolled pieces. Below Koekenaap the high terrace disappears, presumably owing to widening of the valley. I did not find it towards The Point. I could recognize no terraces in the rock-outcrops at about 75 m S.L. above Viswaters on the left bank at the mouth, and pebbles on the slope could be derived from the quartzitic conglomerate or have been carried from the Canal Gravels. There was a scatter of unrolled Late Acheulian and Sangoan. The 45-metre terrace is likely to have graded to a S.L. about 50 m, for which I found no evidence on this section of the coast.

OLIFANTS RIVER TO SOUTRIVIER

Owing to diamond-mining, the only part of this coast whence I can record personal observations is near The Point. North of Toring I must summarize the accounts of Krige (1927) and Haughton (1931). Haughton (p. 31) quotes from Reuning (1931) a detailed description of the beds at The Point. On an irregular cliff-surface at 21,0–26,3 m (W39), clearly not a planed terrace, were lagoonal and deltaic deposits overlain at about 27 m S.L. (W38) by marine beds containing *Crassostrea margaritacea* (formerly *Ostrea prismatica*), *Thais praecingulata* and *Donax*.[3] These beds must equate with those which I saw about 4 km farther north at Cliff Point, Toring (W45). Here the cliff-top is a wide rock-platform at 30 m S.L., clearly corresponding to that at Strandfontein. On it, beneath dune, are marine pebbles, sand and patches of a shell-bed at 31–33 m S.L. The shells were mostly *Crassostrea margaritacea*, with a *Donax* which Carrington identified as *D. haughtoni*, although he considers that farther north this belongs to a shoreline at 45–50 m, and that on the lower terrace there occurs *D. rogersi*. The cliff of the platform is concealed; but its level surface suggests that the base was very little above 30 m.

There are traces at Cliff Point of a terrace at 3,3 m (W46). I have no other evidence for a low-level shoreline as far as Soutrivier.

Near Rooiduin (W47) a gully reveals beneath the dune marine sand and pebbles 4½ m thick on a boulder-bed which rests on rising rock at about 15 m S.L. The deposit must have been laid down, perhaps in deep water, below the top of a transgression. There are no shells. On the eroded dune, from presumably near its surface, I found (N.M. 71/41) two small picks of Sangoan type, pieces of quartz and silcrete which may be M.S.A., and fragments of *Patella*.

Haughton and Krige describe prospects in Klipvley Karoo Kop and Graauw Duinen

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[3] Carrington & Kensley (1969: 215) indicate that Haughton did not distinguish *Donax rogersi* from *D. haughtoni*.

(W 48–52). Beach-deposits have been seen at various levels, with warm fauna at 18 m and above and cold at 6,6 m. Published records are insufficiently detailed to identify separate transgressions and their fauna. The sequence and altitudes are probably identical with those which Carrington has studied north of Soutrivier.

SOUTRIVIER TO KLEINZEE

The whole coast is diamondiferous; I owe my information about it to the courtesy of De Beers Consolidated Mines Ltd and to Mr A. J. Carrington, who is making a detailed study of the shorelines. I can therefore give no more than a very brief summary, because it is not for me to trespass on Carrington's findings which I hope will be published in detail. I will make mention of one or two artefacts, which the geologists have not recorded.

Some 8–15 km behind the coast is a continuous escarpment, most easily accessible on the road from Garies to Hondeklip Baai, where the rock rises from about 42 m to 100 m S.L. and is overlain by 12 m of sand. There is no evidence for marine deposits on it. Its foot varies in altitude up to nearly 90 m; in places marine deposits occur nearly up to this level. In its present form it is not a marine cliff.

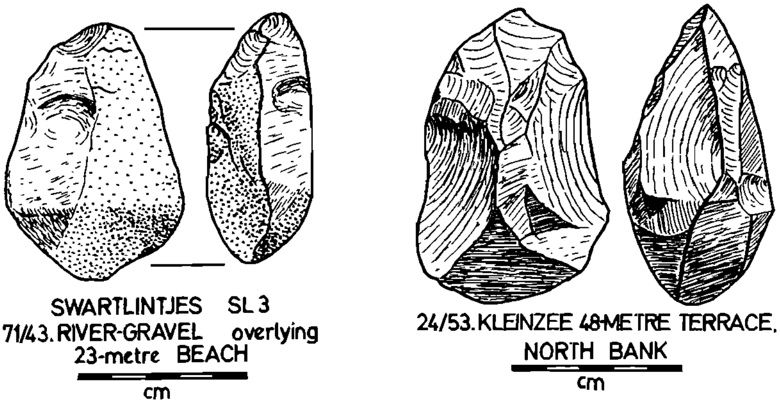
On the sloping coastal plain fragmentary tertiary fluviatile and marine deposits have been overrun by a series of overlapping pleistocene transgressions, few of which have left a noticeable cliff. In places the beaches outcrop on the surface, but in general they are covered by thick terrestrial wash, and are revealed only in the series of prospecting trenches. Previous to this trenching, Krige was unable to recognize terraces higher than 6 m.

Carrington & Kensley (1969: 190) list the altitudes of the marine transgressions south of Hondeklip Baai; Carrington has subsequently revised his list. The highest levels which he recognizes are to 90 m and 65 m. Thus at least one higher level which I have described in the South Cape and in Natal (Davies 1970: 407–8; Davies 1971) is missing in Namaqualand, where near the pliopleistocene boundary ocean-level seems to have been near modern level. A crude rolled industry which I identified in a 9-metre river-gravel at Wallekraal about 20 km up R. Spoeg (N.M. 14/53; Davies 1955) cannot be associated with any high-level beach, though at roughly 90 S.L., because like other small rivers of Namaqualand R. Spoeg descends rapidly to its mouth.

Carrington's next level is at 50 m. This probably equates with my 61-metre level, as most of his figures seem slightly lower than mine from other coasts of South Africa. Typical fauna of this level are *Donax haughtoni* and *Fissurella robusta* (W70 W74 W81).

He has some evidence for a 38-metre level (W82), which presumably corresponds to the 48-metre on other coasts. When I visited him in 1971 he had little fauna associated with this level and no *Donax*. As this level is not well defined, it is unlikely to be equivalent to the wide 30-metre terrace at Toring and Strandfontein.

Much better defined is his 23-metre level (W56 W59 W69 W71 W72 W75 W83), probably the 30-metre terrace of Natal and the south Cape. This beach seems to embody more than one transgressive maximum. Typical fauna are *Donax rogersi* and *Fissurella glarea*; *F. robusta* also occurs. In the marine beds at Swartlintjes SL3 was a rolled piece of quartz, probably an end-struck cleaver; but I did not recognize the type before I found a similar piece in the Canal Gravels at Platzkraal (fig. 6 2), so I cannot illustrate this one. These two pieces confirm the equivalence by altitude of the 23-metre beach and the Canal



SWARTLINTJES SL 3
71/43. RIVER-GRAVEL overlying
23-metre BEACH

24/53. KLEINZEE 48-METRE TERRACE,
NORTH BANK

Figure 8.

Gravels of R. Olifants. Above the marine sands at SL3 is a gritty and pebbly fluviatile deposit; in this I found two probable rolled quartz hand-axes (N.M. 71/43; fig. 8; the second is less convincing).

Carrington appears not to have recognized a level corresponding to the 18-metre sea on other coasts, and his next level is at 9 m with storm-ridge up to 12 m (W86) and cold-water fauna with Mytilids and *Patella*, which occur at no higher level.

The next terrace is at 5,5–6,0 m (W57 W60 W62 W64–7 W78 W84), with cold-water fauna. Three infinite radiocarbon-dates are published from '6-metre' and '9-metre' beaches[4] at Karoetjes Kop (Pta 091–3; Vogel & Marais 1971: 381). It appears that Pta-093 is from Trench KR10 (W57) and Pta 091–2 from Trench KR11 (W60).

What are probably the 9-metre and 6-metre beaches have been identified, neither at their maximum altitude, on the north bank of the Soutrivier estuary (W53–4). Beneath a metre of wind-planed terrestrial and aeolian sediments is a bed of calcified marine sands with a few boulders at base at about 4,8 m S.L. This rests on another bed of sands and boulders, also calcified on the surface. Both beaches have cold-water fauna, and must antedate the over-deepening of the estuary, which at latest will have taken place in the last part of the Würm glaciation. The pebble-bed in the estuary at 2 m S.L. will be holocene (W55). If these two beaches are to be correlated with the 9-metre and 6-metre levels of the South Cape, this section shows that they were separated by a regression, to what depth is unknown.

Carrington identifies two lower terraces at 1,25–2,0 m (W58 W61 W63 W79) and up to 4,5 m. Both have cold-water fauna. The date of 340 ± 50 (Pta-090) for a shell on the 2-metre beach is lower than any published dates for the Dunkirk-Rharb terrace of the North Atlantic, so the piece was probably a casual drop. The terrace up to 4,5 m includes the crest of the storm-beach, so the maximum of the transgression would be near 3,5 m. It is to this transgression that I would assign the storm-ridge at 5-6 m between Hondeklip Baai and Groenrivier (W68) and the shelly estuarine deposits at the road-crossing of R. Swartlintjes (W73), which extend from about +3 m S.L. to at least −5 m, so must have

[4] Altitudes corrected from the printed report by Carrington, *in litt.*

been laid down during a large transgression. At Koingnaas KN5 (W76–7) the 1,5-metre beach incises sands overlain by the 3,5-metre beach. The profile is

M.S.L.	
above 3,5 m	soft white dune
3,5 m	laid pebbles, no cliff exposed
2,1–3,5 m	fairly hard brown sand, such as is elsewhere deposited on the 6-metre beach
1,9–2,1 m	uncemented calcrete blocks above unconsolidated sediment
0,9–1,5 m	laid pebbles, apparently the head of a beach
up to 0,9 m	modern sandy shore.

At Gorab there are three storm-ridges, with crests at 2, 5 and 12 m (W86–8); the first two are probably holocene.

Hardly any artefacts have been found in the beach-gravels. On this arid coast the Lower Palaeolithic occurs only on larger rivers, Orange Buffels and Olifants. It would be expected that the warmer ocean-water indicated by the fauna on the 23-metre and older beaches would have brought more rain to the coast, as is suggested by the massive Canal Gravels of R. Olifants; but man was not induced to occupy the coastlands. In terrestrial deposits above fossil beaches a few fairly recent artefacts have been found:

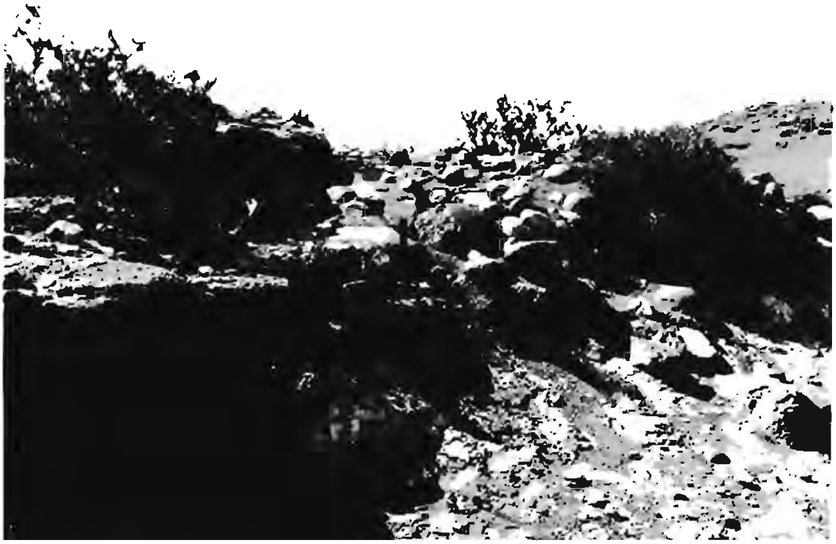
(1) above the two beaches on the north bank of the Soutrivier estuary, midden with *Patella*;
(2) the cover of the 6-metre gravel at Karoetjes Kop KR10 is stratified:
    skin of white mobile dune
    60 cm of brown dune
    calcified clayey surface
    60 cm of wash, containing one sharp quartz chip, atypical
    calcified clayey surface
    3 m of wash; 30 cm below its surface a land-surface with line of scattered stones; unrolled a large end-scraper and a hollow scraper of quartz, N.M. 71/42
    beach-gravel;
(3) above the cliff where the 6-metre beach incises the 23-metre beds at Karoetjes Kop KR11, terrestrial deposit 2½ m thick containing mammal-bones and sharp quartz chips;
(4) at 1 m depth at Langklip one quartz flake;
(5) about 1 m above the estuarine muddy sands at the Swartlintjes crossing an occupation-horizon;
(6) in a thick fluviatile deposit above the 23-metre gravel at Swartlintjes SL3 what may be a rolled cleaver and an unrolled broken pebble (N.M. 71/43), neither very convincing as artefacts;
(7) above thick calcrete overlying the 23-metre gravel at Koingnaas KN3, in a thin calcified layer in dune, shells and two unrolled scrapers, fair-sized and possibly as old as M.S.A. (N.M. 71/44).

No satisfactory explanation has been proposed why ocean-water became markedly colder after the 23-metre beach. It is not unreasonable to associate this beach with the 30-metre terrace in other parts of South Africa and with the Holstein interglacial. There had before this time been severe glaciations in both hemispheres. It is possible that in the Riss a more settled regime of glaciation developed, with marked change of winds and currents, and it may be significant that it was perhaps at this stage that the ocean first sank to very low eustatic levels and that coastal valleys began to incise deep trenches (Davies 1971: 218).

KLEINZEE TO RIVER ORANGE

The diamond-mines at Kleinzee have been intensively worked for many years. Little detail has been published about them, but I was able to visit them in 1953 and again in 1971, when much of what I saw on my earlier visit had been destroyed.

Above fluviatile pliocene beds at 35 m S.L. (Stromer 1931) is a series of pleistocene



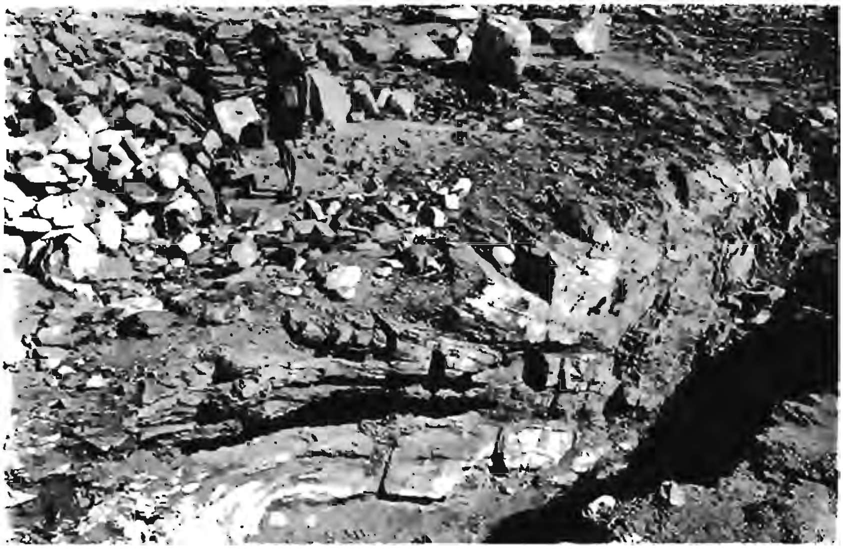


Figure 9.
Upper: Kleinzee W90, 60-metre terrace, edge of cliff.
Lower: Kleinzee, head of gorge debouching on the 48-metre terrace.

beaches from about 90 m. The highest beach with cliff is exposed at Twee Pad (W97); no artefacts have been found in it. No terrace at 73 m has here been recognized. Incised into the 90-metre terrace is a terrace at 60 m with cliff (W90, W98; fig. 9 upper). No fauna has been found in it, perhaps owing to the coarseness of the sediment and the dilution of salt water by R. Buffels; but I collected one pebble which had probably been worked to an irregular scraper (N.M. 71/45; fig. 10). South of R. Buffels, in an area now mined out and built over, gravels about a metre thick covered a long gullied slope from 63 m S.L.; stratification had been mixed by mining. The only possible but unconvincing artefacts were two nibbled pebbles. I found two probable pebble-choppers on a narrow 60-metre terrace backed against a cliff just north of R. Buffels (Davies & Walsh 1955: fig. 4 14; N.M. 52/53). In presumably terrestrial sands above the beach at this point were unrolled hand-axes (?Middle Acheulian) and midden-material with *Patella*.

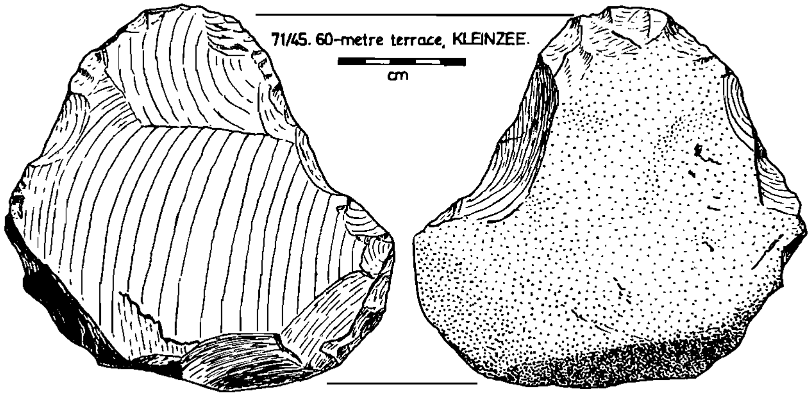


Figure 10.

There were slight traces of a narrow terrace with cliff at 53 m (W91).

The widest terrace has its cliff-base at 48 m (W92). On the south bank a gorge from about 53 m S.L. and smaller streams debouched at this level. The gully was filled with poorly bedded gravels without artefacts (fig. 9 lower; Davies & Walsh 1955: fig. 3). It presumably had been a course of R. Buffels, and the perched mouth at this altitude indicates that there had not been previous eustatic entrenchment unless to seaward on a slope now removed by erosion. In a small working on the north bank at 48 m I found in a marine gravel about 80 cm thick two rolled slabs with several flakes off the edge (Davies & Walsh 1955: fig. 4 15; N.M. 24/53), and a small hand-axe with arrises blunted probably by sand-blasting (fig. 8). The latter might be contemporary with the terrace, but looks typologically more recent. In 1971 I was shown evidence that this terrace may have been older than and overrun by the 60-metre transgression; similarly, at Alexander Bay, it appears from a diagram in De Villiers & Söhnge (1959: 221) that the 39-metre beach was overrun and partly removed by the 44-metre transgression. This reconstruction would avoid contradiction with the beach-sequence in the south Cape, where the 48-metre level was unimportant in comparison with those at 61 m and 30 m. The 48-metre level in the west Cape must then mark a temporary tectonic submergence between the oldest pleistocene beaches and the 61-metre sea, or else be part of the transgression from the low-level pliocene ocean to the very high level near the beginning of the Pleistocene.

I was in 1971 told of evidence for beaches at 39 and 32 m at Kleinzee; there is no clear evidence for beaches at 18 m and 13 m; Hallam (1964: 707) records a level at 23 m, but I have no other evidence for it. The 32-metre level is the best developed (W94); the only fauna recorded is *Turbo cidaris*, a mainly cold-water form.

On both banks of R. Buffels I have seen a beach up to about 8 m S.L. (W89 W93), and probably another rather higher (Geological Survey, 1959). It was however difficult to distinguish them on the fairly constant slope, and no certain cliffs are identifiable. To one of these beaches presumably graded the 13,5-metre terrace on R. Buffels above the Kleinzee gorge (Davies & Walsh 1955; Davies 1955), on which I found unrolled pieces which seem Late Acheulian or Sangoan, an ovate hand-axe, pebble-picks, perhaps a cleaver, a large scraper and a pebble-chopper (in South African Museum, Cape Town). At the south end of Kleinzee Bay two layers of sand at 7–8 m, overlying lines of cold-water shells, may indicate two overlapping transgressions. In the dune above them on the south bank was a large midden containing *Patella*, whale-bones, ostrich-eggshells, stone pounders, quartz and chert flakes and no pottery. Lower storm-ridges at 5 m and 3 m (W95–6) probably belong to holocene transgressions.

It must have been near Twee Pad that Rogers (Haughton 1931: 29) made a mixed collection of shells, perhaps from two terraces combined, 'near the north end of the Game Reserve' (W85). Near Oubeep terraces with fauna are recorded by Haughton and others. The highest is at 68 m, with many large pebbles (Geological Survey, 1959); no cliff or fauna is recorded. Haughton speaks of shelly gravel with cold-water fauna at Oubeep (W99) at 12–19 m.

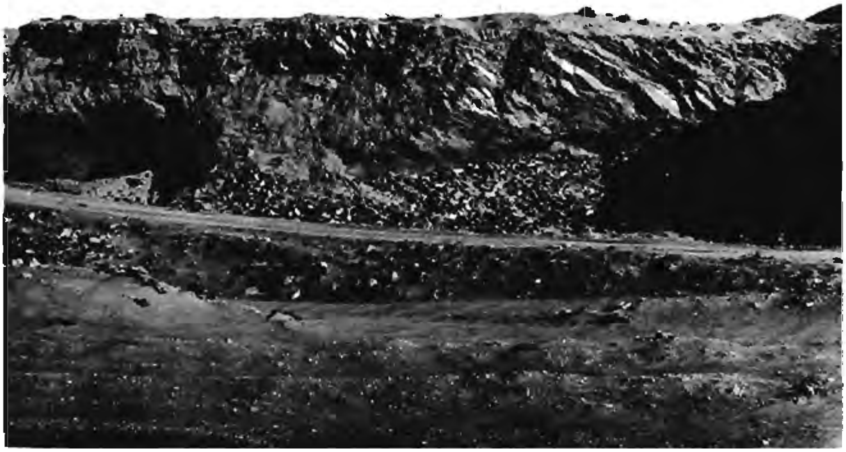
On the road behind Port Nolloth is a beach at 60 m at the foot of a cliff (W101). Small nibbled pebbles in the gravel were unconvincing as artefacts; but a large pebble (Davies & Walsh 1955: fig. 4 13) had been split longitudinally before trimming round the edge; I doubt if this could be done naturally.

There is a marine terrace at 8 m at Port Nolloth (W102).

I visited Alexander Bay with Mr Walsh in 1953. An authoritative account of the marine terraces has been published by De Villiers & Söhnge (1959); but most of their data was collected in or before 1944.

The main terrace at Alexander Bay is the Middle Terrace, with notched cliff at 29–25 m S.L. (W114; fig. 11 upper), apparently ripple-warped; it has been recorded without cliff at several places as far south as Holgat. It yields warm-water fauna. It is presumably to be correlated on fauna and altitude with Carrington's 23-metre terrace in Namaqualand. Despite similar altitudes, I am uncertain of its equivalence to Beach D at Orange Mouth, because there Beach C still contains warm fauna. There may have been tectonic movement along the Orange valley.

The faunal lists for the Middle Terrace at Alexander Bay given by Haughton (1931:27) and De Villiers & Söhnge (1959: 230–1) must be treated with caution, as they may combine fauna from the Middle Terrace and from a later beach (? the 'Operculum-terrace') incised into it. Most of the fauna that they list is warm-water; but the *Patella*-species seem out of



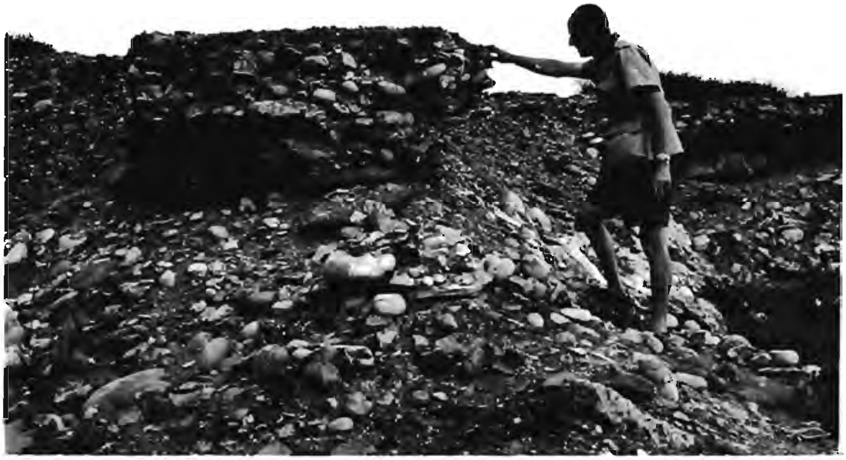


Figure 11.
Upper: Alexander Bay W114, cliff of Middle Terrace at 29–25 m.
Lower: Alexander Bay W110, 8-metre beach at Dinkel's Prospects.

place in this assemblage.

I collected from the gravel of this terrace close to its cliff many rolled chipped pebbles (N.M. 18/53; Davies & Walsh 1955: fig. 5 7–12). Some of these seem to have been naturally broken. Others, viz. a primitive hand-axe (12), a type of cleaver (7), several longitudinally split pebbles and some large cores, are unlikely to have been fashioned by the sea and seem to have been artefacts (see fig. 12). Such split pebbles occur also on Terrace D at Orange Mouth. In favour of many being artefacts, it is to be argued that none have been found either on the 39-metre terrace at Alexander Bay, or at sites away from R. Orange, for instance at Uub Vlei only 20 km to the north, though it might be expected that such places would have been exposed to similar conditions of storm and waves. On the other hand, the pieces claimed as artefacts are remarkably formless, and the Middle Terrace is probably not older than Middle Acheulian, when recognizable tool-types were regular. However, I have examined quartzite pebbles at other places exposed to Atlantic surf, on Jura (Scotland), at Malin Head (Ireland) and Senya Beraku (Ghana), and have nowhere found longitudinally split pebbles of the type which near R. Orange seem the most convincing artefacts (Davies 1957). Pieces nibbled round the edge are less convincing. Some may be artefacts; on one large piece seven large flakes had been removed from alternate faces.

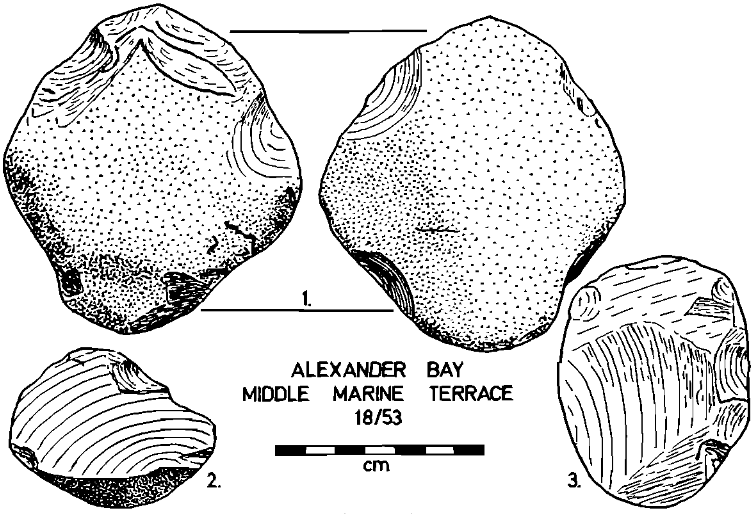


Figure 12.

De Villiers & Söhnge have at Alexander Bay identified three terraces higher than 27 m, at 48, 44 and 39 m (W111–3). The second seems to have overrun and been later than the third. Its cliff peters out 2½ km south of R. Orange and does not appear on the north bank. A diagram (De Villiers & Söhnge 1959: 235–6) shows its gravel overlying and protruding beyond the cliff of the Middle Terrace in T30; but as they never saw the section personally, it is not clear what it signifies or whether their reconstruction of complicated crustal movements is correct. All save the highest terrace had marine beds with *Crassostrea margaritacea*.

The correlation of these marine terraces with the terraces of R. Orange is not clear. On altitude one would expect the 39-metre terrace to be equated with the 36-metre terrace at Kaross, on which I have found unrolled probably Acheulian and M.S.A. (N.M. 67/53); and the 27-metre beach with a terrace at 28 m at the beacon not far south of Oppenheimer Bridge and at 25 m at Kaross, whence I obtained unrolled Late Acheulian hand-axes, flakes and a pebble-chopper (N.M. 62/53, 66/53). But the absence of a High Terrace north of the river indicates tectonic instability, and makes correlations uncertain; terraces farther upstream at Sendelings Drift bear no altitudinal relation to the shorelines.

In Trench 39 at Alexander Bay we saw at about 21 m S.L. an incision into the Middle Terrace gravel (W115), truncating the beds of marine pebbles and sand and the reddish terrestrial sand overlying them; the whole sequence was covered by some 30 cm of calcified sand, which must therefore be fairly recent. The transgressive beach had not removed the older marine beds to bedrock. Its gravels gave out at 18 m S.L., but probably reappeared as a concentration at about 15 m. Where they had been removed, dune overlay the remnants of the Middle Terrace beach. The transgressive beach contained cold-water fauna, no oyster but mussel and limpet. This unconformity was noticed by Haughton and identified with the Operculum-terrace. It seems in general not to have been found north of Trench 39, and was not noticed by De Villiers & Söhnge, who list a combination of warm and cold-water species from the Middle Terrace (pp. 230–1); but in fig. 13 they give a section of 'an unconformity in the gravel of the Middle Terrace' in Trench 6, which probably belongs to the same transgression. It is unlikely that this is the equivalent of Beach C at Orange Mouth, which contains warm-water fauna. It could be the 18-metre terrace of the south Cape, which has been rarely identified in Namaqualand; for the faunal change probably took place after the 23-metre S.L. there.

The sloping rock-floor, apparently planed by the 27-metre sea, continues to about 12 m S.L. at Dinkel's Prospects. Here a transgression to about 8 m overlaps rock, lagoon-muds and the calcrete cap of the older regressive beaches. It carries about 4 m of gravel (fig. 11 lower) containing cold-water fauna (listed by Haughton 1931: 29; other spp., coll. Davies & Walsh 1953, id. L. C. King: *Balanus* sp., *Bullia rhodostoma*, *Crepidula porcellana*, *Oxystele sagittifera*, *Patella longicosta*, *Thais cingulata*, *T. squamosa*, *T. ? wahlbergi*, *Trigonephrus haughtoni* (terrestrial)) and unrolled pebble-choppers (N.M. 19/53) which look fairly recent. I am inclined to think that part of this deposit corresponds not to Beach B at Orange Mouth but to Beach A.

De Villiers & Söhnge regarded a platform at 15 m (we measured about 12 m) on the two promonotories bounding Alexander Bay as part of the Middle Terrace, and thought that it occurs round the bay at 11 m. The divergence of altitude they explained by local warping. It is not clear what fauna it yielded. It is more likely to be the 21-metre transgression which may have reworked some Middle Terrace gravel, or else an independent transgression at a lower level. It probably correlates with the 12-metre river-terrace near the aerodrome. This is at the base of a long slope from the 27-metre terrace, and is covered by some thickness of poorly bedded gravel, in which I found a rolled hand-axe and point (N.M. 65/53; fig. 13) and two unrolled pieces, one of which may be a M.S.A. core (N.M. 63/53). A very narrow terrace at 10 m is incised into the 12-metre terrace along the river-bank, and there are traces of another at less than 9 m with unrolled M.S.A. flakes (N.M. 64/53).

The 18-metre terrace at Grootderm may be the same as the 12-metre at the aerodrome,

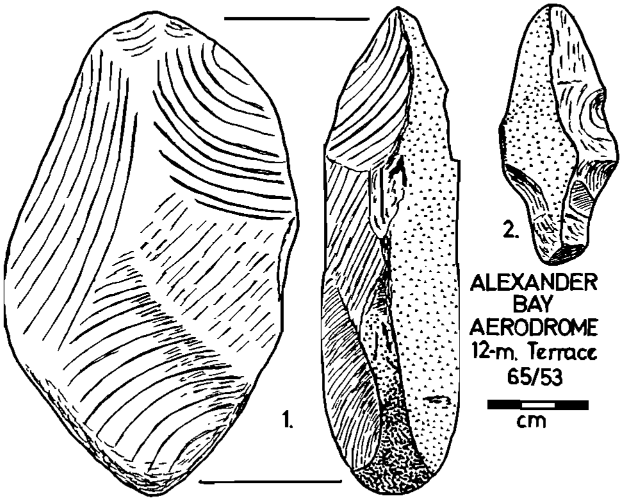


Figure 13.

as all the terraces dip seaward from upstream. The gravel is about 2½ m thick, so the rock-terrace would be near 15 m above river. On this gravel I found a small unrolled hand-axe (N.M. 68/53).

The 20-metre terrace on the north bank is older than Beach D.

RIVER ORANGE TO WALVIS BAY

This stretch is closed except for a small area around Lüderitz, which I was able to examine on my own. North of Lüderitz is very difficult country with high mobile dunes right to the coast; a few beach-exposures are known, but little has been published (Hallam 1964). South of Lüderitz there is some published information, and much is known by the geologists of Consolidated Diamond Mines of S.W.A. Ltd. The most detailed account hitherto published is by Hallam. An older account, especially of the northern exposures, is given by Haughton (1931) with some lists of fauna. I was able to visit the area in 1953 and 1967, up to about 80 km north of Orange Mouth; I give a very short summary, pending publication by Dr Stocken and his colleagues. Submarine platforms, cliffs and channels are described by Murray *et al.* (1970).

In 1967 four wave-cut platforms were recognized as extending from Oranjemund northwards, dipping very gradually to the north. They are distinguishable by lithology, by fauna and by stream-channels which one or more of them overrides.

Beach D is well developed as far as Chameis; north of this, where the coast steepens, it disappears. It rests on a gullied rock-bench with well-marked notched cliff, with base at about 25 m; or close to R. Orange on poorly sorted river-gravels, which apparently formed a bar across the estuary. Near the river its surface is at over 30 m. The pebbles are flattish and well bedded, some fairly large as far as Uub Vlei but decreasing in size farther north.

Beach D has several crests, believed to mark halts in a long regression. I measured them at Gemsbok at 30, 24, 22 and 20 m. The deposits are bedded at a slight angle to the rock-platform. The surface is heavily calcified, with sand-blasted pebbles and terrestrial molluscs; above it is illuvial red sand.

Beach D carries a warm-water fauna, especially *Donax rogersi.*

In the decalcified crest of the 20-metre ridge at Gemsbok I counted about twenty rolled broken pebbles. Many were nibbled and doubtful artefacts. A chopper, a borer and a split pebble are more convincing (N.M. 23/53; fig. 14). I found also several unrolled quartzite artefacts, flakes, a few cores including a low pyramid, a large chopper and a crudely made pick (fig. 15). The industry seems to be Sangoan.

Dr. Bascom obtained a date of > 28000 (I-1094) from barnacles in a gully in the platform of the 'upper terrace' (D) at about 6 m S.L. 5 km north of R. Orange.

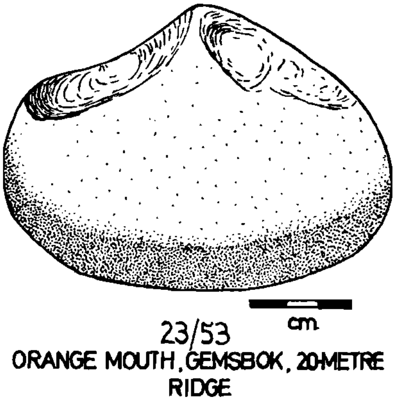


Figure 14.

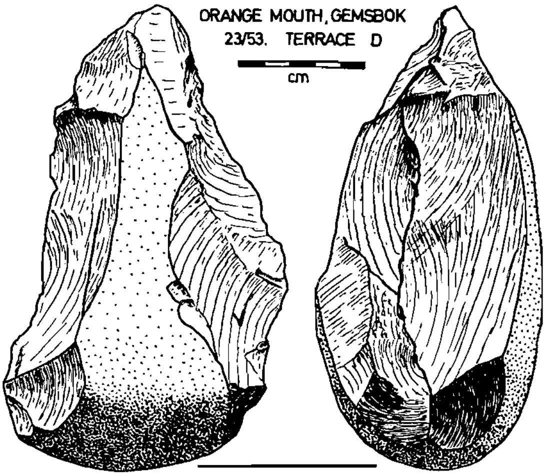


Figure 15.

Platform C is well marked near R. Orange, with maximum altitude of 13 m. It thins out northward and at 55 km from the river appears to have been eroded by B. It carries warm-water fauna, including *Donax rogersi*; consequently it cannot be correlated with the 21-metre transgression at Alexander Bay. In 1953 C was not distinguished as an independent beach, but must have been a concentration of pebbles which I saw at about 15 m in the lower part of the Gemsbok workings.

In 1967 I did not recognize artefacts in Beach C, only a few rolled nibbled pebbles and one possible split pebble. In 1953 I found in the lower gravel a large pick-like piece which may be a rolled artefact (N.M. 17/53), and on the surface many unrolled quartzite flakes and several choppers, perhaps Sangoan.

The exposures which in 1953 I saw at Uub Vlei may also have belonged to Beach C. Deeply gullied bedrock was gently rising at about 12 m. On the rock were pebbles cemented with silicified sand, overlain by about 2 m of bedded marine sand with small and large pebbles, rising more steeply than the basal gravel. Shells which I collected were identified by Professor L. C. King as *Crassostrea margaritacea* and *Lutraria lutraria*; Haughton (1931: 23) lists warm-water fauna including *Donax rogersi* and *Fissurella robusta.* I saw nothing at Uub Vlei which could be accepted as an artefact.

Close to R. Orange the crest of Platform B is at about 8 m and the cliff-base about 5 m. The cliff is notched, with incipient caves. It probably correlates with a river-terrace at the same height on the north bank. The beach dips slowly northwards, and to it may belong the planed bar at just over 0 m at Bogenfels noted by Haughton and a storm-beach at about 4 m. This beach carries cold-water fauna of modern type; lists are given by Haughton.

At South German Workings near Orange Mouth I found on the crest of Beach B a very few unrolled Late Acheulian pieces, a pick, a chopper and a flake; also a lightly rolled long pebble, split by a side-struck blow to resemble a uniface hand-axe and utilized near the point (N.M. 22/53; fig. 16). On the crest at 32G was a large unrolled high-backed core,

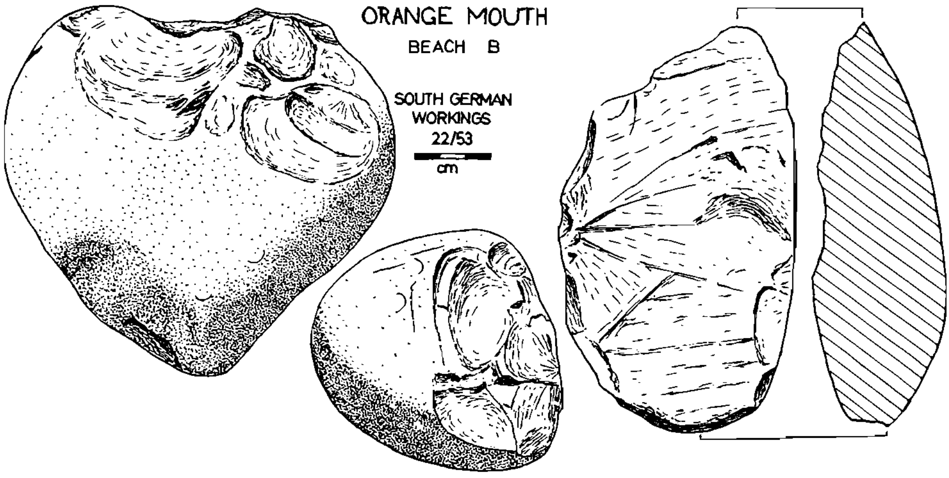


Figure 16.

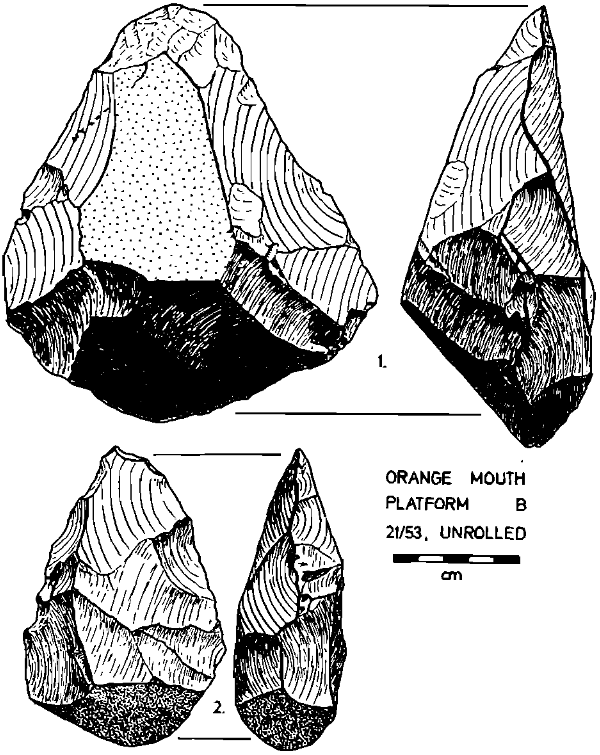

1.
2.
ORANGE MOUTH
PLATFORM B
21/53, UNROLLED
cm

Figure 17.

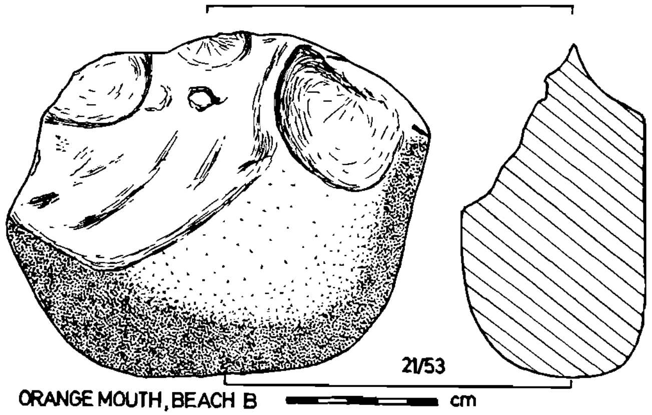

21/53
ORANGE MOUTH, BEACH B
cm

Figure 18.

a piriform biface hand-axe (fig. 17), two or three picks, a chopper and flakes. Near 121G was an unrolled lanceolate hand-axe. I collected also from this beach rolled broken and split pebbles. Some could well be Late Acheulian cores or large flakes. At 121G only one had several flakes removed. At 32G there were choppers and borers (N.M. 21/53; fig. 18). In the South German Workings were several rolled pieces, including two very large cores and two choppers (fig. 16).

Beach A can be traced to about 80 km north of R. Orange; near the river its crest is at 3–4 m S.L. It carries modern cold-water fauna. No rolled artefacts have been found associated.

The following dates have been obtained from cold-water shells on Beach A:
from 2-metre terrace about 56 km north of the river (Vogel 1970)

GrN-4571	38100 ± 500
GrN-4572	35000 ± 630.

Seaward of the eocene beds at Kolmanskop behind Lüderitz, I found no beach-terraces older than holocene. A bank of shell-fragments and marine pebbles up to 6 m M.S.L. against a rise in rock at the north end of Grosse Bucht (SWA 2; 26°45′00″S 15°06′20″E) is probably a storm-ridge of the 3,5-metre ocean. Ridge-crests at 6,3 m and 9,6 m with rock-rise behind at Sturmvogelbucht may be structural rather than the remains of marine terraces. The 3,5-metre level occurs at:

SWA 4, Halifax, 26°39′20″S 15°05′00″E.
SWA 6, East side of Diaz Point isthmus, 26°38′40″S 15°05′30″E; pebbles, beach-rock and cave at 4,5 m
SWA 8, Sturmvogelbucht, 26°38′30″S 15°07′20″E; with cliff
SWA 9, Griffith Bay, 26°38′30″S 15°08′00″E
probably at Elizabeth Bay, 26°56′S 15°12′E; 4-metre terrace, see Hallam (1964).

A date for *Patella* from the beach at Sturmvogelbucht is 4930 ± 60 (Pta-419).

I saw three exposures of the 1,5-metre beach. At the south end of Grosse Bucht (SWA 1, 26°46′40″S 15°06′40″E), seaward of a bank of stones and pebbles up to 3 m S.L., which is continued at the south edge of the bay by an undercut cliff and rock-terrace, is a large bed of shells at 1,5–1,8 m, truncated by a low cliff to the level of the modern beach. A date on shell from this beach is Pta–417, 1170 ± 50. The other exposures are shell-banks with crests at 1,8 m and 2,5 m on each side of the isthmus to Diaz Point Lighthouse (SWA 5, west side, 26°39′00″S 15°05′15″E; SWA 7, east side, 26°38′50″S 15°05′20″E, south of SWA 6). The following fauna was identified by Mr. R. N. Kilburn:

from SWA 1 *Aulacomya ater (= crenatus)*
Bullia digitalis
Bullia laevissima
Burnupena papyracea
Conus mozambicus
Patella barbara
Patella compressa
Patella granatina
Patella granularis
Thais squamosa
Turritella carinifera;

from SWA 7 *Argobuccinum argus*
Bullia digitalis
Burnupena delalandei
Burnupena papyracea
Conus mozambicus
Patella barbara
Patella compressa
Patella granatina
Patella granularis
Patella miniata
Siphonaria capensis.

WALVIS BAY TO RIVER UGAB, THE OLD BEACH

With Mr R. C. Walsh I visited parts of this coast in 1955, and again in 1970 when the whole stretch was unrestricted and there was a good road as far as R. Ugab. The coastal deposits used to be regarded as riverine or terrestrial gravels (Hallam 1964); but prospecting has revealed *Crassostrea margaritacea* in many of the gypsified deposits of what I would call the Old Beach. This should be correlated with Platform D at Orange Mouth. It is uncertain whether there are any remains of Platform C, which disappears about 50 km north of R. Orange, because the Old Beach north of Walvis Bay is fragmentary and prospecting has been at random and not by long trenches which would reveal the stratigraphical succession.

I am certain that there are no marine deposits above the Old Beach or above 29 m S.L. At SWA 51 I explored the slopes of the escarpment, the poort through it and the plain behind, and found no trace of marine beds. On both banks through the poort are rock-shoulders 8 m above river-bed, and small quartz pebbles to this level. It therefore appears that all earlier beaches have been drowned by tectonic action, and the very low platform which I describe below may be a stage in the transgression which brought the sea to about 29 m. In Angola also there is a hiatus in the sequence between the 20-metre beach and a very high Early Pleistocene one (Davies 1959; Clark 1963: 236–45). At Orange Mouth Beach D overlies the filling of the gorge, entrenched to —90 m and therefore cut before the Middle Pleistocene, though it may have been partly reopened in recent eustatic low sea-levels.

At many exposures (SWA 24 25 26 27 29 31 33 36 42 56) only a fragment of the Old Beach, lower than its original maximum height, survives as an Inselberg with cliff to landward. Its nature is indicated by the shells which it contains.

The clearest indication of the maximum altitude of the Old Beach is at SWA 51, below the poort through the escarpment of the first river 8 km north of Cape Cross and 2,6 km east of the road. The beach has spread over a very gentle slope, and in the river-bank are well-laid rolled pebbles, including erratics, interbedded with gypsified sands, up to the crossing of a track at 26 m M.S.L. (fig. 19; Davies 1956). These gravels appear marine, though no shells were found. The deposit is at least 3 m thick; rock is not exposed. In the meanders above the track there appear in the banks irregular lines of poorly rolled pebbles and angular material interbedded with silts rather than sands. These beds are riverine, and a slight steepening of the surface-slope may indicate a degraded cliff at this point. The exposure is local; the marine deposits disappear to the south where bedrock changes from lava to schist. They may be seen to the north in smaller valleys and at the next stream 2½ km to north (SWA 52) at 28 m. The only artefacts from SWA 51 were two flakes on the surface of the beach below its summit.

Elsewhere the Old Beach dies out at 26–29 m S.L. on a gentle slope with no clear sign of a cliff. At SWA 11, behind Walvis Bay, is a wide spread of well rounded pebbles, mostly of quartz, set in gypsum at 27–29 m. On the scraped surface are a few shell-fragments, some of oyster. The pebbles end against a rise which may indicate a cliff.[5] At SWA 20, 3,7 km north of Swakopmund Municipality, there are pebbles and a few erratics but no oyster up

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[5] I recently learnt that this beach is traceable for a long distance along the old road to Swakopmund behind the mobile dunes which overlook the coast.

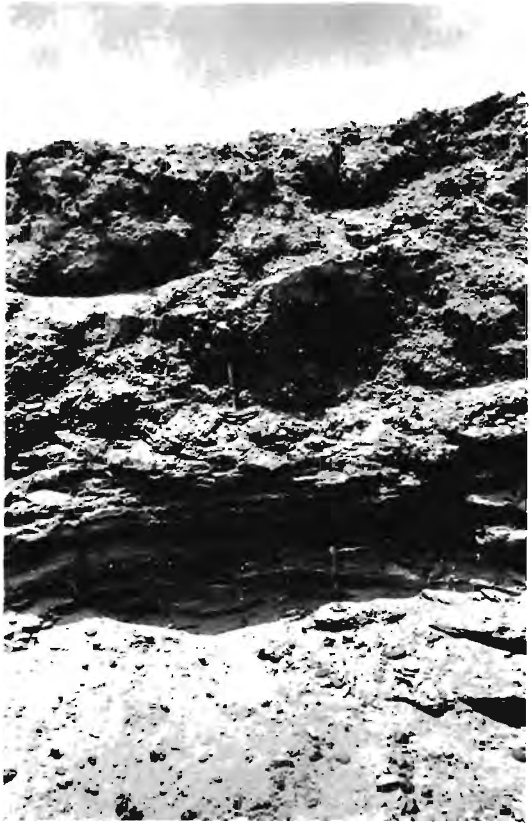

Figure 19.
SWA 51, North of Cape Cross, gravels and sands at the head of the 26-metre beach.

to 27 m. At SWA 54, on the road to the Brandberg West Mine, are prospects up to 24 m S.L. in valleys which could have acted as diamond-traps, while on the interfluves the beach-gravel is > 1,2 m thick. There are marine pebbles but no oyster. There are no pebbles on a slight rise farther inland at 26 m, which may be the remains of the cliff. At SWA 14, near the road-bridge over the railway south of Swakopmund, is a patch of pebbles, quartz schist dolerite granite and quartzite, some of them erratic, without oyster up to 27 m where it disappears beneath dune. Spreitzer (1965–6) records a terrace at 25 m in the dunes in this area.

The poort of River Swakob through a calcite ridge marks the head of an estuary at 24 m S.L. (SWA 17); the rock-floor is not exposed. Above the railway-bridge was a lake with rock-terrace whose covering of grit and pebbles rises to 42 m, corresponding to a terrace of 40 m in the poort. There are no shells in the gravel, and no evidence that it is marine. On it I found a weathered Late M.S.A. core. Subsequently the bar was incised to below 24 m, after which indurated false-bedded sands, layered silts and gravels accumulated above and through the poort to 33 m S.L. This terrace was then incised to the modern river-bed. On the old Windhoek road I found a weathered blade at the foot of the 42-metre cliff, and two unrolled pieces, perhaps Acheulian, on the slope above it.

On R. Ugab (SWA 62) a rock-terrace at 18 m very slowly rises landwards. It may form the floor of a 4-metre covering of silts, and be continuous with SWA 61, ½ km south of the river at 22 m, where pits have revealed many rounded and erratic pebbles, but no shells.

The Old Beach consists of heavily gypsified sands with bands of well-rolled pebbles, among which are usually a few erratics not derived from immediately local rocks. At two sites it was possible to measure the stratification in prospecting pits:

SWA 26, Fishery Beacon 39,0 km north of Swakopmund, pit sunk in a surviving fragment of the beach at 13,5–19,5 m S.L. To east the beach is removed, but may have extended 1½ km to the base of a long ridge which is at 27–30 m.

cm 0–102	Mixed reworked gypsified beach-material
102–127	Browner sandy layer with small pebbles
127–152	Mauve beach, probably silicified; pebbles and very large *Ostreidae*, gen. et sp. indet. (Kilburn)
152–213	Brown sand
213–244	Laid pebbles
	Rock.

SWA 27, fragment of beach from 13,5 to 16 m M.S.L., 44,1 km north of Swakopmund and east of the road. The band of pebbles is fairly thin, and is overlain by about 1 m of gypsified grit which seems largely terrestrial. Behind the beach-Inselberg there are no further signs of beach up to 27 m S.L. at 4 km from the coast. At this altitude the slope steepens with quartz outcrops, and there may be the remains of a cliff.

cm 0–45	Gypsum. Pebbles in disorder. A few *Ostreidae*
45–130	Gypsum-cemented lumachelle with larger shells at base; few pebbles. The only recognizable shell is *Crassostrea margaritacea* (Kilburn).
130–142	Laid pebbles in iron-stained gypsum
	Rather pockety surface of rotten schist.

The fauna in the Old Beach is very limited; apparently gypsification has destroyed almost all molluscs. Fragments of Ostreidae were found at SWA 11 26 29 36 and 42. At SWA 25 27 and 33 *Crassostrea margaritacea* was recognized, at SWA 25 also *Dosinia ? orbignyi*, at SWA 56 *Ostrea ? stentina.*

The only rolled artefact found in the Old Beach gravels is a broken pebble, apparently flaked on upper and under side (N.M. 70/28, from SWA 56), perhaps a core of Perdehof-type, unsuccessfully struck. Unrolled flakes, perhaps L.S.A., were found at Gregory Point (SWA 15) on what appeared to be the eroded surface of the Old Beach at 14–16 m S.L., a core, flakes, blades and an end-scraper.

WALVIS BAY TO R. UGAB, THE VERY LOW PLATFORM

The very low platform is exposed intertidally at +0,3 – —0,9 m on certain stretches:

8–16½ km north of Walvis Bay
near SWA 14 to the south bank of the Swakob estuary
at the bathing-beach in Swakopmund

SWA 32, planation of a dolerite dyke at −0,6 m
from the point south of Hentiesbaai (22°11′00″S) with some gaps as far as the fishing-beacon north of the Omaruru mouth, SWA 40, 22°05′00″S)
near Camp 72, SWA 44, rocks at about −1,0 m may form part of the platform
not observed in the rocky area of Cape Cross, but it may form the floor of the salt-pans south of the cape
Spreitzer (1961) records a shore-terrace south of R. Unjab (about 20°11′S), which may be part of this platform; I could not reach this area.

This platform is near Swakopmund cut in granite or dolerite. Near Hentiesbaai it is formed apparently of beach-rock, cemented grit with rounded pebbles. At SWA 40 it is cut in a cemented conglomerate of sand and angular grit, like terrestrial wash. At SWA 37 it seems to pass beneath the silts, perhaps an old mouth of R. Omaruru, into which is incised the 9-metre terrace. Elsewhere it may pass beneath the gypsified grit which forms the covering of the Old Beach. It may therefore be part of the platform on which the Old Beach rests, or, as suggested above, an older platform formed during the transgression to the Old Beach. But I could obtain no definite evidence for its date, and the S.W.A. Geological Survey have been unable to make any suggestion.

WALVIS BAY TO R. UGAB, THE 18–20 METRE TERRACE

At SWA 14 a cliff, with base at 18–20 m, is incised into the grits of the Old Beach. At the top of Swakopmund there used to be traces of a cliff with surface at 21 m S.L. and base concealed, probably about 18 m (SWA 19). It was incised both into rock and into cemented sands and gravels. It formed the top of the Town Terrace, which rises very gently from 13 m. At SWA 20 36 and 57a this terrace is incised into the Old Beach. At SWA 36 50 and 55 weathered shells of *Donax serra* were found on this terrace; they are probably associated with it, but could have been carried by man.

At SWA 13, 8 km north of Rand Rifles station, in a pit landward of the road are banks of sand and grit, some sharply current-bedded, with layers and pockets of pebbles and a little fine sand, capped by fine sand and hardened mud. The beds are over 3 m thick, and lightly cemented. Some of the pebbles appear marine, others are sub-angular. The deposit does not appear to be marine, but was probably formed in a vlei associated with the 18-metre transgression. It would have been separated from the sea by a bar.

Another fossil vlei which on altitude may be associated with the 18-metre transgression is SWA 60. A prospecting pit reveals the following sequence:

M.S.L. 12–10,1 m	horizontally bedded gravels and sands
10,1–8,1 m	horizontally bedded silts, slightly eroded
8,1–<7,2 m	grits with false bedding
	rock not exposed.

This was probably a coastal vlei behind a bar, the breaking of which, perhaps as the sea transgressed to its maximum, may have spread the surface-gravel. The vlei extended more than 1 km inland and its cliffs can be seen. Landwards the silts pinch out and are replaced by horizontal gravels and cross-bedded grits.

Near Cape Cross slight warping of the tertiary basalts seems to have produced anomalous beach-levels. In SWA 49 a line of beach-pebbles, many erratic, can be traced at 13–16m

M.S.L. for several kilometres round bays and headlands at the back of a large salt-pan (Davies 1956). On this beach were found unrolled flakes, and on the slope 3 m above it a uniface hand-axe struck from a Victoria West core. The same level, covered with small pebbles, appears on the summit of Tobacco Island (SWA 45, 12 m above pan-surface). Downstream from SWA 51 are pebble-layers interbedded with sands at 13–14 m, apparently banked against a cliff (SWA 51a). As the top of the Old Beach at SWA 51 is at 25–6 m, slightly lower than the usual level on this coast, it is probable that these occurrences at 13–6 m are warped beaches of the 18-metre sea-level. At SWA 49 there is a concentration of large pebbles at 21–24 m.

Korn & Martin (1955) speak of rolled M.S.A. in the 18-metre gravels at the mouth of R. Omaruru. On other coasts of southern Africa the 18-metre level is older than the M.S.A.; so these pieces may have been Levallois-type flakes of Late Acheulian date, or else sand-blasted but unrolled.

WALVIS BAY TO R. UGAB, THE 9-METRE TERRACE

The 9-metre marine terrace is well developed with rise behind, which seems to mark a degraded cliff (SWA 21 50 53 56 57 57a; probably 54; probably 23, perhaps reworking the Old Beach). Fossil pans associated with this S.L. occur at SWA 22 and at the turn to Strathmore Tantalite (SWA 59). There are corresponding terraces at the mouths of certain rivers, some of which are at anomalous altitudes between 18 and 9 m, at which it is unlikely that there have been transgression-maxima, so they probably belong either to the 9-metre S.L. at a time when the coast was farther seaward, or to a halt in the regression from the 18-metre sea:

SWA 19. At the southern edge of the town-terrace at Swakopmund a narrow terrace with pebbles used to be visible at 13 m above river; probably Spreitzer's (1965–6) 12-metre terrace; see Davies (1956). This terrace seems to approach 9 m above river farther up the former estuary, as the modern river-bed is graded to a lower S.L.

SWA 37. Near the point south of Hentiesbaai a terrace at 9 m forms the surface of sandy silts, which may have formed in a former mouth of R. Omaruru during its transgression to this altitude. A very shallow valley is traceable for 2 km inland, and at the side the terrace is incised into a sandy cliff. On the terrace are a few pebbles, including erratics, and shells of Mytilids and other gasteropods, which could have blown in from the modern shore. Farther south the terrace is rock-cut.

SWA 39. The village of Hentiesbaai stands on an 18,0–20,6 metre terrace. Incised into it on the north bank of the stream is a terrace at 15 m S.L. (Spreitzer's 16 m), perhaps belonging to the regression.

SWA 40. At the Omaruru mouth the principal terrace is at 18–20 m. It may be traced for some distance along the coastal cliffs. Incised into it in the estuary is a narrow terrace at 17,4 m, carrying weathered Mytilids and *Donax serra*. This may belong to the regression. Below this is a third terrace at 12 m, which at the first Omaruru tributary to the north forms a hanging valley incised into gypsified sands with a dry waterfall. This stage could well belong to a S.L. lower than the present, with coastline well to the west.

SWA 62. On the south bank of the Ugab estuary is a well-marked terrace rising from 9,6 to 11 m. Spreitzer (1965–6) records two terraces at 10 m and 12 m; but I saw no trace of more than one. On this terrace I found an unrolled L.S.A. end-scraper (N.M. 70/29), perhaps also M.S.A. pieces, and shells of *Donax serra* and a few of *Choromytilus meridionalis* (perhaps blown from the modern beach).

At other sites of the 9-metre terrace I found *Donax serra* (SWA 50 57 57a). On SWA 57 were also *Thais squamosa* and *Perna perna*.

WALVIS BAY TO R. UGAB, THE 6-METRE TERRACE

There is little evidence along this stretch for a 6-metre S.L. There used to be a terrace at this altitude at the south-west corner of Swakopmund, close to the mouth of the estuary, now probably incorporated in the Esplanade; Spreitzer claimed Mousterian artefacts on it. At SWA 32 there is a beach-deposit of pebbles, including erratics, and *Donax serra* on a gentle rise from 3,0 to 6,3 m, at which altitude they die out. A pebble-concentration from 3–6 m S.L. at SWA 54 is probably the head of a beach. I saw no sign of a 6-metre terrace at the Omaruru mouth, which Spreitzer records.

WALVIS BAY TO R. UGAB, THE HOLOCENE BEACHES

There are many occurrences of beaches at 3–4 m and 1–2 m. A few are rock-cut with cliff, more often they are marked by a bar or storm-ridge in front of a fossil vlei. It is sometimes difficult to distinguish a fossil from the modern storm-ridge, as the throw may not have been constant and occasionally there may be ridges intermediate between the two which I have defined. Fauna is modern, and is listed in Table 3.

The only artefacts found on these beaches are from SWA 30, a flake and perhaps some struck pebbles.

TABLE 3

MOLLUSCS FROM HOLOCENE BEACHES BETWEEN WALVIS BAY AND RIVER UGAB

Ident. Kilburn, except 45 (id. G. Lecointre; Davies, 1956) and 45a (from Gevers, 1931). Kilburn has corrected obsolete names.

* Not recorded as living south of Angola.
** Recorded as living in both Angola and South West Africa.

SITE (see key)	10	12	18	34	35	43	45	45a
Amblychilepas scutellum		×						
**Apolymetis papyracea*			×					
***Barnea truncata*	×							
***Bullia callosa*	×			×				×
digitalis	×		×					
laevissima	×		×					×
**Bursa marginata*				×				
Choromytilus meridionalis	×							
**Cymatium parthenopeum*							×	
?**Diplodonta* sp.				×	×			
Donax serra	×	×	×	×	×	×		
{ *Dosinia lupinus*							×	×
**{ *? orbignyi*	×	×	×	×	×			
**Loripes ? aberrans*				×				
* *liratula*				×				
Lutraria sp.			×					
**Macoma ? cumana*	×							
Marginella capensis	×		×					
Mytilus sp.							×	
***Nassarius plicatellus*			×				×	
scopularcus	×		×	×				
sp.	×							
?**Ostrea* sp., *? stentina*		×						

SITE (see Key)	10	12	18	34	35	43	45	45a
Patella granatina							×	
***Perna perna*	×					×		
Siphonaria capensis							×	
***Tapes corrugatus*	×	×				×	×	
Tellina madagascariensis								×
Thais capensis							×	
** *haemastoma*		×		×		×		×
squamosa		×						
Turritella bicingulata	×							

KEY TO SITES

10. WALVIS BAY, east side of lagoon, 22°57′10″S 14°29′30″E. Terrace of sand and broken shells at 1,5 m S.L., incised by the modern beach. The shell-sample may be contaminated from modern specimens, as it was collected where washed out from the old on to the modern beach. *Marginella capensis* is included; it was not found on the beach, but Dr E. Scherz informed me that it was dredged in large numbers from the harbour, and perforated shells were found with beads of ostrich-eggshell on an archaeological site 8 km to the south.
12. Fossil vlei 2,7–6,5 km north of RAND RIFLES STATION, 22°48′00″–46′20″S 14°32′10–00″E. Vlei-surface at 1,8 m M.S.L., covered with shell-fragments and a few granite pebbles; at north end banks of pebbles 3 m thick and up to 3,6 m M.S.L., mixed with shell and resting on the grey clay of the vlei-bottom; the crest is not exposed and the ridge may be a storm-ridge. The numerous pebbles suggest an old river-mouth.
18. SWAKOPMUND, estuarine terrace 4 m above valley-floor and about 6 m S.L., at south-east end of the town, 22°40′40″S 14°32′30″E. Patches of shells on the outer edge of the terrace, apparently natural accumulation and not the remains of a midden.
34. 54,7 km north of Swakopmund, 22°14′40″S 14°22′30″E. Perhaps a fossil vlei-bed at 2,1–3,6 m M.S.L. beside the road; shells stop at 3,6 m, though there are large pebbles higher up the slope.
35. 55,5 km north of Swakopmund, 22°14′20″S 14°22′30″E. Beach with pebbles and shells at 3,9 m S.L. In it found a sand-blasted quartz flake (N.M. 70/30).
43. 33,5 km north of Hentiesbaai crossroads, 21°53′20″S 14°07′20″E. Vlei-surface at 1,2–1,5 m M.S.L., occasionally flooded by very high tides. Shells on exposures of a dolerite dyke were left by a sea higher than present.
45. GUANO ISLANDS, 21°48′S 14°00′E. Basalt islands in a large pan south of Cape Cross, insulated by transgression to 2,1 m M.S.L. with high tides up to a notch at 3 m. Their slopes are covered to 3 m with rock-waste and small pebbles, which overlie gypsified shelly sand. See Davies (1956).

45a. Patches of shelly sand in the pan, formed before it was completely cut off from the sea. From Gevers (1931).

ADDITIONAL NOTES ON BEACH-SITES FROM WALVIS BAY TO R. UGAB

(Localization; beaches identified at each site — O = Old Beach, 18 = 18-metre, 9 = 9-metre, 6 = 6-metre, 4 = 3–4 metre, 1½ = 1½–2 metre; and other details not in the text.)

11. Walvis Bay, just seaward of the aerodrome, 22°58′40″S 14°38′00″E. O. Pages 756, 758.
13. 8 km north of Rand Rifles station, 22°45′30″S 14°32′30″E. 18. Page 759.
14. Near the road-bridge over the railway, 22°45′00″S 14°31′30″E. O, to 27 m; 18, incised into O with cliff 4½ m high. Incised into this another terrace, cliff-base not exposed, at some distance seaward at 3 m M.S.L. The rock-terrace is prolonged behind the modern storm-ridge by sand, on which are many large *Donax serra*. The modern beach carries little but Mytilids. Pages 757, 759.
15. Gregory Point, in 1955 at MS 1120½–1122 on railway (mile-posts now altered), about 22°43′20″S 14°30′50″E. Two storm-ridges behind the modern, the crest of the inner at 3½–4 m M.S.L., with root-concretions of ferricrete and calcrete. Behind this, cliff-base at about 4½ m, incised into a platform at 14–16 m, which may be part of the Old Beach. See Davies (1956). Page 758.
17. Swakob Poort at the railway-bridge, 22°40′50″S 14°34′30″E. Pages 757–8.
18. Swakob estuary, 22°40′40″S 14°32′00″E. 6. Table 3.
19. Swakopmund town, 22°40′S 14°32′E. 18, 9. Pages 759–60.
20. Vineta, close to the dynamite-house, 22°37′40″S 14°32′30″E. O, 18. Pages 756, 759.
21. 6½ km north of Swakopmund Municipality, 22°37′00″S 14°32′00″E. 9, 4. Page 760.
22. 13,5 km north of Swakopmund, 22°33′50″S 14°31′00″E. 9. Page 760.
23. 14,5 km north of Swakopmund, 22°33′30″S 14°32′00″E. 9 and perhaps O. Page 760.
24. 22,5 km north of Swakopmund and 1,5 km east of the road, 22°29′00″S 14°29′30″E. Stretch of the Old Beach with pebbles, 120 cm thick, at 12–20 m S.L., broken away at back. Page 756.
25. Wlotskasbaken, 300 m east of the main road, 22°24′50″S 14°27′30″E. Two Inselbergs of the Old Beach, >2 m thick, at 15–18 m and 16–22½ m S.L., with many shells. Pages 756, 758.
26. Fishery Beacon 39,0 km north of Swakopmund and 1½ km from the coast, 22°22′20″S 14°27′20″E. O. Page 758.

27. 44,1 km north of Swakopmund and 1 km east of the road, 22°19′00″S 14°26′00″E. O. Page 758.
29. 48,1 km north of Swakopmund, 22°17′20″S 14°25′20″E. Inselberg with pebbles and shells. O. Pages 756, 758.
30. 49,3 km north of Swakopmund, 22°17′10″S 14°24′40″E. Storm-ridge at 3,0 m between two vleis, carrying many pebbles and *Donax serra*. To seaward two low dune-ridges, which have probably formed on other storm-ridges. Behind the innermost vlei a rise to a flat at 4,5 m with pebbles, probably the outer part of a higher terrace. Page 761.
31. 50,5 km north of Swakopmund, 22°16′30″S 14°23′40″E. Inselberg with a fragment of the Old Beach at least 3 m thick, at 10,5–12,6 m S.L. Page 756.
32. 52,8 km north of Swakopmund, 22°15′30″S 14°22′40″E. 6. Page 761.
33. 54,2 km north of Swakopmund, 22°14′50″S 14°22′40″E. O. Pages 756, 758.
36. 55,5 km north of Swakopmund, 22°14′20″S 14°22′50″E. O, 18. Pages 756, 758–9.
37. Hentiesbaai Point and south, 22°10′00″–13′30″S 14°17′40″–20′30″E. South of the point a long fossil vlei at 3,0 m, bounded seaward by the modern storm-ridge and landward by a fossil storm-ridge and a much gullied cliff composed of sandy silts. Probably 9, 4. Page 760.
38. 22°10′00″S 14°18′00″E. Surface-scatter of pebbles with a few erratics at 24–27 m; no sign of cliff and no prospecting-pits. O.
39. Hentiesbaai, 22°09′00″S 14°17′20″E. River-terrace at 4,6 m (6,6 m S.L.), dipping seaward; I could not tell to what S.L. it graded. At the mouth of the valley, estuarine fan at 1,5 m. 18, ? 4, 1½. Page 760.
40. Omaruru mouth, 22°07′00″S 14°14′20″E. Estuarine flood-plain at 2½ m rising slowly upstream. 18, probably 9, ? 1½. Page 760.
42. 33 km north of Hentiesbaai crossroads, 21°53′40″S 14°10′30″E. Inselberg with a fragment of the Old Beach, probably reworked, at 25½–27 m S.L. Pages 756, 758.
44. Camp 72, 21°51′30″S 14°05′30″E. Vlei-bed at 1,8 m M.S.L., bounded seaward by the modern storm-ridge. Behind it an irregular quartzite outcrop, bounding a low platform with storm-ridge at 5,4 m, bounding probably a fossil vlei.
45. Guano Islands in the salt-pan south of Cape Cross, 21°48′S 14°00′E. Some of the islands, especially Tobacco Island, preserve remains of a dissected vlei-bed with small quartz pebbles at 12 m above pan = 14 m M.S.L. Probably part of the 18-metre terrace, slightly warped. Again insulated by a sea with M.S.L. about 2,1 m. See Table 3.
49. East of the large salt-pan at Cape Cross, 21°47′S 14°02′E. Probably O and 18, slightly warped. Pages 759–60
50. Cape Cross Bay, 21°46′00″S 13°57′20″E. Storm-ridge behind the modern at about 3½ m, 9, probably 1½. Pages 759–61.
51. Below the first poort through the escarpment 8 km north of Cape Cross, 21°42′20″S 14°00′00″E. O, fig. 19. Page 756.
51a. Downstream from 51. Probably 18, slightly warped. Page 760.
52. North of 51, about 21°39–41′S 13°59′E. O. Page 756.
53. 25,9 km north of Cape Cross, 21°32′S 13°52′20″E. Vlei-bed at 1,2 m carrying quartz pebbles, *Donax serra* and a few Mytilids; storm-ridge at 3,9 m. 9, ? 1½. Page 760.
54. On the road to Brandberg West Mine, 21°29′20″S 13°52′20″E. O, 18, 9 probably, 6 probably. Pages 757, 760–1.
55. 39,7 km south of Ugab bank, 21°27′00″S 13°50′30″E. 18. Page 759.
56. 37,8 km south of Ugab bank, 21°26′20″S 13°50′20″E. Beach-gravels up to 150 cm thick on yellow sand. O, 9 incising the Old Beach. Pages 756, 758, 760.
57a. 37,6 km south of Ugab bank, 21°26′20″S 13°51′30″E. O, 18, 9. Pages 759–61.
57. 36,3 km south of Ugab bank, 21°26′00″S 13°51′30″E. 9 probably incising O. Pages 760–1.
58. 34,2 km south of Ugab bank, 21°25′00″S 13°52′00″E. Terrace covered with very small rounded pebbles at 16 m. Probably another gravel-terrace at 9 m. Below it another at 8 m, perhaps a storm-ridge, and vlei at >6 m. Incised into the 8-metre ridge, storm-ridge at 3,8 m.
59. At turn to Strathmore Tantalite, 21°14′00″S 13°45′00″E. 9. Page 760.
60. 7,7 km south of Ugab bank, 21°12′30″S 13°43′30″E. Fossil vlei, probably 18. Page 759.
61. 0,5 km south of Ugab bank, 21°10′30″S 13°41′10″E. O presumably. Page 758.
62. Ugab mouth, 21°12′00″S 13°38′09–20″E. At the mouth terrace of silty sand at 3 m with storm-ridge at 3,6 m; and terrace of clayey silt at 1,2 m. Also probably O and 9. Pages 758–60.

CONCLUSIONS

In general, the western coast of South and South West Africa seems to have been little warped as far back as the Late Middle Pleistocene, and there is good agreement with altitudes on other stable coasts. Behind this stage, there is some agreement in Namaqualand, but the South West African beaches have disappeared, having been presumably drowned by a considerable submergence. This holds also for Angola.

Attempted correlations with other parts of the world are conjectural. It is possible to identify approximately similar levels for the last interglacial; but Hoyt's attempt (1967) to compare South West Africa with Georgia is not acceptable as far back as Orange Mouth Beach C. Few isotopic dates are at present available behind the range of radiocarbon, and they do not seem trustworthy. Comparison of human industries in the Old World makes it likely that the sea-level at ±30 m is the glacio-eustatic level of the Mindel-Riss interglacial; but behind that stage the northern glacial sequence is itself uncertain, so high sea-levels cannot be anchored to well-defined points in the glacio-climatic sequence. We cannot even say that the oldest beaches containing artefacts must still be pleistocene, and we are not certain that the altitude of a beach correlates with its age. So one can do no more at present than record occurrences, in the hope that one day it may be possible to fit them into a chronological frame. This has been a large part of the work of the Shorelines Commission of the International Quaternary Association.

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BIBLIOGRAPHY

Barnard, K. H., 1962. Revised list of South African late tertiary and pleistocene marine mollusca. *Trans. Roy. Soc. S. Afr.* **36** (iv): 179–96.

Carrington, A. J. & B. F. Kensley, 1969. Pleistocene molluscs from the Namaqualand coast. *Ann. S. Afr. Mus.* **52** (9): 189–223.

Clark, J. D., 1963. The distribution of prehistoric culture in Angola. *Acts V Panafrican Congress on Prehistory* **1**: 225–309.

Davies, O., 1955. The Sangoan culture of Little Namaqualand. *Acts III Panafrican Congress on Prehistory*: 219–22.

——— 1956. Pleistocene raised beaches in South-west Africa. *XX Int. Geological Congress, Acts of the Association of African Geological Services*: 347–50.

——— 1957. Pebble-tools of the early pleistocene beaches at the mouth of the River Orange. *V Inqua, Résumés des communications*: 45.

——— 1959. The raised beaches of Angola and South-west Africa. *Acts IV Panafrican Congress on Prehistory* **1**: 289–94.

——— 1970. Pleistocene beaches of Natal. *Ann. Natal Mus.* **20** (2): 403–42.

——— 1971. Pleistocene shorelines in the southern and south-eastern Cape Province (Part 1). *Ann. Natal Mus.* **21** (1): 183–223.

——— 1972. Pleistocene shorelines in the southern and south-eastern Cape Province (Part 2). *Ann. Natal Mus.* **21** (2): 225–79.

Davies, O. & R. C. Walsh, 1955. Raised beaches and associated stone-age material in Namaqualand. *S. Afr. J. Sci.* **51**: 277–82.

De Villiers, J. & P. G. Söhnge, 1959. *Geology of the Richtersveld.* Pretoria: S.A. Geological Survey, Memoir **48**.

Du Toit, A. L., 1917. *Report on the phosphates of Saldanha Bay.* Pretoria: S.A. Geological Survey, Memoir **10**.

Geological Survey, 1959 (4th edition). *The mineral resources of the Union of South Africa.* Pretoria.

Gevers, T. W. & J. P. van der Westhuyzen. 1931. The occurrence of salt in the Swakopmund area. *Trans. geol. Soc. S. Afr.* **34**: 61–80.

Hallam, 1964. 'Geology of the coastal diamond deposits of Southern Africa', in *The Geology of some ore deposits in Southern Africa*; edited by S. H. Haughton, vol. 2, pp. 671–728. Johannesburg: Geological Society of South Africa.

Haughton, S. H., 1931. Late tertiary and recent deposits of the west coast of South Africa. *Trans. geol. Soc. S. Afr.* **34** 19–57.

——— 1933, *The Geology of Capetown and adjoining country.* Pretoria: S.A. Geological Survey, Explanation of sheet 247.

Hendey, Q. B., 1968. The Melkbos site. *Ann. S. Afr. Mus.* **52** (4): 89–119.

——— 1970*a*. Review of the geology and palaeontology of the plio/pleistocene deposits at Langebaanweg. *Ann. S. Afr. Mus.* **56** (2): 75–117.

——— 1970*b*. Age of the fossiliferous deposits at Langebaanweg. *Ann. S. Afr. Mus.* **56** (3): 119–31.

Hoyt, J. H., 1967. Intercontinental correlation of late pleistocene sea levels. *Nature* **215** (5/8/1967): 612–14

Kensley, B. 1972. Pliocene marine invertebrates from Langebaanweg. *Ann. S. Afr. Mus.* **60** (4): 173–90.

Korn, H. & H. Martin, 1955. The pleistocene in South-west Africa. *Acts III Panafrican Congress on Prehistory*: 14–22.

Krige, A. V. 1927. Examination of the tertiary and quaternary changes of sea-level in South Africa. *Ann. Univ. Stellenbosch* **5**, A i, 81 pp.

Mabbutt, J. A., 1955. Some quaternary events in the winter rainfall area of the Cape Province. *Acts III Panafrican Congress on Prehistory*: 6–13.

——— 1956. Physiography and surface geology of the Hopefield fossil site. *Trans. Roy. Soc. S. Afr.* **35** (1): 21–4.

Murray, L. G., R. H. Joynt, D. O'C O'Shea, R. W. Foster & L. Kleinjan, 1970. 'The geological environment of some diamond deposits off the coast of South-west Africa', in *The Geology of the East Atlantic continental margin*; 1 *General and economic papers*; edited by F. M. Delany, pp. 123–41. Natural Environment Research Council, Institute of Geological Sciences, Report 70/13.

Olsson, I. & K. G. Eriksson, 1969. 'Fractionation studies of the shells of foraminifera', in *Etudes sur le Quaternaire dans le monde*; edited by M. Ters, vol. 2, pp. 921–3. Paris; VIII Inqua.

Parker, R. J., 1968. *Eustatic shorelines of Saldanha Bay.* Unpubl. BSc thesis, Geology Department, University of Cape Town.

Reuning, E., 1931. The Pomona quartzite and oyster-horizon on the west coast north of the mouth of the Oliphants River. *Trans. Roy. Soc. S. Afr.* **19**: 205–14.

Singer, R. & J. Wymer, 1968. Archaeological investigations at the Saldanha skull site. *S. Afr. Archaeol. Bull.* **23**: 63–74.

Spreitzer, H., 1961. Forschungsreise der österreichischen geographischen Gesellschaft nach Afrika 1961. *Mitt. d. österr. geogr. Ges.* **103**: 294–5.

Spreitzer, H., 1965–6. Beobachtungen zur Geomorphologie des zentralen Namib. *J. S. W. Afr. Sci. Soc.* **20**: 69–94.

Stromer, E., 1931. Reste süsswasser- und land-bewohnender Wirbeltiere aus den Diamantfeldern Klein-Namaqualandes. *Sber.d. bayerischen Akad. Wissensch.* **1931**: 17–47 (quoted by Hendey, 1970*b*).

Vogel, J. C., 1970. Groningen radiocarbon dates IX. *Radiocarbon* **12**: 444–71.

Vogel, J. C. & M. Marais, 1971. Pretoria radiocarbon dates I. *Radiocarbon* **13**: 378–94.

Wybergh, W. 1919. The coastal limestones of the Cape Province. *Trans. geol. Soc. S. Afr.* **22**: 46–67.

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ADDENDUM

This paper went to press before the publication of H. J. W. G. Schalke, 'The Upper Quaternary of the Cape Flats Area' (*Scripta Geologica* 15, Leiden), which discusses low mid-Würm sea-levels at Riet Vlei. I hesitate to accept the suggestion of continuous uplift of the area; and caution should be exercised on the correlation with European interstadials, as some of Schalke's radio carbon-dates seem to be on molluscs, high dates of which are unreliable. New also is U. Keyser's monograph (Geological Survey, Bulletin 54), which gives a detailed picture of terraces between Alexander Bay and Port Nolloth.